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Macario Rodríguez-Entrena*, Manuel Arriaza

Department of Agricultural Economics and Rural Sociology. Institute of Agricultural Research and Training (IFAPA), Córdoba, Spain.

* Corresponding author: Macario Rodríguez Entrena, Instituto de Investigación y Formación Agraria y Pesquera (IFAPA) - Avda. Menéndez Pidal s/n Córdoba (Córdoba), E-14080, Spain,
E-mail: macario.rodriguez@juntadeandalucia.es

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Macario Rodriguez-Entrena*, Manuel Arriaza

Department of Agricultural Economics and Sociology, Institute of Agricultural and Fisheries Research and Training (IFAPA), Córdoba, Spain.

* Corresponding author: M. Rodriguez-Entrena. E-mail: macario.rodriguez@juntadeandalucia.es

Abstract

The adoption of Soil Conservation Practices (SCP) in olive groves in Andalusia, such as not burning olive-desuckering debris, shredding olive-pruning debris for use as soil cover and using cover crops under mower control, constitutes a huge advance towards sustainable olive growing. By adopting such SCP, olive growers can reduce the worrying level of erosion this activity causes, combat climate change and increase biodiversity. In this sense, the negative spillovers associated to the foregoing processes are highly significant both in qualitative and quantitative terms regarding the degradation of agricultural ecosystems. This paper seeks to identify the main factors that affect these SCP in olive groves in Andalusia. In order to do so, we use a trivariate probit model, therefore considering that the reasons behind adopting SCP may be interrelated. The results show how the factors that determine the adoption of such practices are related to the socio-demographic characteristics of olive growers, some of the characteristics of the olive grove itself and how it is managed and the role of social capital.

Keywords: olive groves, conservation agriculture, adoption, social capital, trivariate probit.

1. Introduction

The olive oil sector in Andalusia (Spain) has grown substantially over the last two decades, producing more than 1.3 million tonnes of olive oil in 2011, which represents 84% of the total for Spain (MAGRAMA, 2012a) and 40% of world production (IOC, 2012). This growth has mainly been due to an expansion and intensification of olive groves, which cover 1.5 million hectares, that is, 16% of the total surface area of Andalusia and 33% of total farm land (MAGRAMA, 2011).

According to data from Erosion National Inventory (MAGRAMA, 2012b), erosion is one of the foremost environmental problems in Andalusia, which is also the Spanish region that is most affected by serious erosion processes[1]. The olive oil sector is not exempt from this reality due to the inappropriate soil management practices employed by olive growers, who keep the soil permanently bare, removing weed cover crops and burning olive-desuckering and pruning debris systematically (Nekhay et al., 2009; Gómez and Giráldez, 2010). Moreover, soil erosion produces other negative externalities, including the pollution of rivers and bodies of water (Colombo et al., 2005), reservoir clogging, degradation of landscape (Parra-López et al., 2009), contribution to climate change (Rodríguez-Entrena et al., 2012) and loss of biodiversity. It is also worth highlighting the on-site effects, as such practices reduce soil fertility and therefore olive grove productivity, apart from increasing production costs to maintain the level of output (Calatrava-Leyva et al., 2007).

EU policymakers have undertaken successive reforms of Common Agricultural Policy (CAP) in order to reduce the negative externalities of farm activity, encouraging the provision of non market goods through joint production processes that favour multifunctionality and sustainability. In this regard, CAP has called for the agricultural model to respond to the overall interests and concerns of European citizens, searching for a sustainable agricultural paradigm that contributes with economic

[1] Some 23% of the total surface area of Andalusia suffer from erosion rates in excess of 25 t/ha·a year.

viability and environmental quality and enhances the quality of life for farmers and rural dwellers (Salazar-Ordóñez et al., 2011). Thus, CAP has been reformulating[2] agricultural land use policy (De Graaff et al., 2013), redefining the limits of farmer property rights to achieve the goals of social legitimacy and sustainability (EC, 1997; EC, 2010). Some of the instruments employed to this end include making cross-compliance progressively tougher, decoupling subsidies and developing agri-environmental programmes. In this sense, the practices to combat erosion prescribed by the requisites of cross-compliance oblige olive growers to leave a cover crop of at least one metre wide in olive groves with a slope of more than 10%. Furthermore, when the slope exceeds 15%, no tillage operations can be performed on the soil (CAP, 2009).

By considering the negative externalities of inadequate soil management in the olive groves of Southern Spain, the present study aims at identifying the factors which determine the adoption of Soil Conservation Practices (SCP), namely no burning of olive-desuckering debris, shredding of olive-pruning debris as soil cover and the use of cover crops under mower control. In order to do so, an empirical application is carried out on a sample of olive groves in the region of Andalusia using a multivariate probit model.

The importance of the study lies, in the first place, in simultaneously modelling the influence of an exogenous variable on the adoption of SCP considering possible correlations among them. In the second place, performing the analysis at regional level allows us to ascertain the endogenous peculiarities and characteristics of these producers, which in turn could yield valuable information for the design of specific environmental programmes under Rural Development Policy (RDP, EC, 2011).

The next two sections of the paper define the conceptual framework of the research and describe the sample of olive groves used. In the fourth section the results and discussion regarding the factors that explain the adoption of SCP in the region of Andalusia are presented. Finally, the last section presents some conclusions aimed at improving agricultural and environmental policy.

2. Background information on the adoption of soil conservation practices

The adoption of SCP in agriculture has been studied since the 1950s (Ervin and Ervin, 1982). According to Feder and Umali (1993), the adoption process is based on a sequence of decisions that individuals make to adopt or reject an innovation. From a micro-level approach, the adoption process can be interpreted as individual adoption behaviour when a series of intrinsic and extrinsic factors determine adoption. In contrast, a macro-level approach examines the adoption process over time to identify a specific functional form within the aggregate diffusion pattern.

Generally speaking, studies aim to relate the factors linked to farms and farmer characteristics that affect the adoption process using different econometric models (Norris and Batie, 1987; Feder and Umali, 1993; Knowler and Bradshaw, 2007). The literature provides multiple factors that influence the adoption of agricultural innovations, of which the following are most frequently mentioned: farmer age and human capital qualifications, generational renewal, social capital, management capacity, availability of machinery, type of land ownership, farm size, crop performance, farm profitability and type of soils (Rahm and Huffman, 1984; Feder and Umali, 1993; Abadi-Ghadim and Pannell, 1999; Knowler and Bradshaw, 2007). Notwithstanding, following the review of the literature, it is worth underlining that the factors that determine the adoption of SCP are not conclusive and difficult to extrapolate from one region or crop to another (Knowler and Bradshaw, 2007).

At European level Prager and Posthumus (2010) systematise the socio-economic factors influencing farmers' adoption of SCP by category. Lahmar (2010) finds that soil conservation concerns do not appear to be the main drivers behind European farmers' decision to make the change, or not, to

[2] Since the signing of the Treaty of Amsterdam at the end of the 1990s and the Treaty of Nice some time later, EU policy has significantly shifted to focus on citizen structures, actions and behaviour, with the precept that policy interventions must reflect citizens' preferences in order to be efficient.

conservation agriculture. In Spain various authors have studied the adoption and diffusion of agricultural innovations (Gómez-Muñoz, 1988; Martínez-Paz et al., 2003; Carmona et al., 2005; Alcón et al., 2006; Parra-López et al., 2007; Franco-Martínez and Rodríguez-Entrena, 2009; Calatrava and Franco-Martínez, 2011), but very few have explored the adoption of SCP, the research by Calatrava-Leyva et al. (2007) figuring prominently.

3. Analytical and Econometric Framework

This study employs a micro approach to analyse which factors determine the behaviour of olive producers in Andalusia regarding the adoption of certain SCP[3], namely:

1. Not Burning Olive-Desuckering Debris[4] (NBODD)
2. Using Shredded Olive-Pruning Debris as soil cover[5] (SOPD)
3. Cover Crops under Mower Control[6] (CCMC)

These farming practices are the Best Management Practices (BMP) currently available and they are also compatible because they are used to perform different olive grove management tasks. These practices account for a large proportion of olive grove management, as they encompass olive desuckering and pruning and how to handle weeds. More specifically, not burning olive-desuckering debris mainly helps to combat climate change. Using shredded olive-pruning debris improves soil texture and also acts as inert cover to reduce the impact of rain and water run-offs. Finally, adopting cover crops under mower control has proven to be the most eco-compatible option, as it protects the soil the most[7]. In this sense, if olive grove managers opt for more eco-compatible practices such as those described above, the sustainability of the olive growing sector and its impact on social wellbeing would increase (Gómez-Limón and Arriaza, 2011; Rodríguez-Entrena et al., 2012).

Bearing this in mind, this research proposes an econometric model following a micro-level approach which explains the adoption decision-making process by means of both the economic constraints and the adopter perception paradigm (Prager and Posthumus, 2010). We do not, therefore, analyse the pattern of aggregate adoption over time to indentify the specific trends in the technology diffusion cycle. Instead, we indentify the intrinsic and extrinsic factors that determine farmers' SCP adoption behaviour. As regards the sample of olive groves, 25% have adopted CCMC, 40% SOPD and 50% NBODD, respectively (these figures measure how much these BMP had spread at a specific time). In this regard, the adoption decision-making process was modelled when technology innovations were not in the final stage[8] of the diffusion process[9], following Rogers (2003).

3.1. Sampling procedure and data

The sample is intended to be representative of Andalusian olive orchards, for which reason a multi-stage sampling procedure has been employed (Gómez-Limón and Arriaza, 2011). In the first place, we

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[3] Prior to implementing the questionnaire, a group of experts selected the most important SCP alternatives in the region.

[4] Olive-desuckering is normally performed between August and September, removing the annual shoots that require a large amount of energy and therefore reduce the harvest.

[5] Olive-pruning is normally performed after the harvest is collected (February-March) at variable regularity (between 1 and 3 years), although olive trees are normally pruned on a two-year basis. The reason for pruning is to preserve the leaf-to-wood ratio, apart from airing the tree to prevent the emergence of pests and diseases and therefore improving output.

[6] Weed management is the greatest challenge faced by olive groves in Andalusia. There are normally two large categories, namely bare soil and soil with cover. Bare soil is either tilled or not tilled, but treated with herbicides, while soil with cover is tilled, treated with herbicides or mown. The cover is normally removed when it begins to compete with the olive trees for water. When this occurs depends on which of the foregoing management techniques has been used. Weeding normally implies the latest cover removal date, due to the time required to carry out this operation.

[7] There are other ways to manage plant covers, such as chemical mowing and minimal tillage, but they are considered less sustainable than mechanical mowing due to use of biocides and soil structure alteration, respectively.

[8] Feder and Umali (1993) warn that many factors are no longer significant when technology has reached the final stage of the diffusion process.

[9] It is assumed that the cumulative adoption curve follows a logistic function (S-curve).

selected 6 agricultural districts[10] in Andalusia out of a total of 52 using a proportional random procedure according to olive grove surface area. The sample covers 474,405 hectares and accounts for 32.4% of the olive orchards in Andalusia. In the next stage of the procedure, 80 personal interviews were conducted per district (480 in total) following quota sampling by olive orchard. Taking into account that the adoption of conservation practices may be influenced by cross-compliance, the sample finally chosen included 232 olive farms with an average slope of less than 10%, that is, the olive groves that are not required to comply with adoption. However, the sample average slope exceeds 5.2% (standard deviation of 3.033)

In order to examine the decision to adopt SCP, we considered farmers' socio-demographic profile, social capital indicators, farm characteristics and farm management. These dimensions are frequently accepted as common predictors of conservation agriculture adoption. Table 1 presents the descriptive statistics of the variables used in the econometric model.

Table 1. Descriptive statistics of input variables

Variable	Denomination	Mean	CV	Units
Dependent variables				
No burning olive-desuckering debris	*NBODD*	0.39	1.25	0 or 1
Shredded olive-pruning debris as soil cover	*SOPD*	0.51	0.99	0 or 1
Cover crops under mower control	*CCMC*	0.26	1.68	0 or 1
Overlaps among dependent variables				
*NBODD * SOPD*		0.30	1.52	0 or 1
*NBODD * CCMC*		0.15	2.42	0 or 1
*SOPD * CCMC*		0.18	2.13	0 or 1
*NBODD * SOPD * CCMC*		0.13	2.55	0 or 1
Explanatory variables				
Farmer socio-demographic profile				
Gender	*MALE*	0.99	0.11	0 or 1
Age	*AGE*	51.79	0.23	Years
Descendants	*CHILDREN*	0.81	0.48	0 or 1
Education level	*EDU_LEVEL*	2.13	0.41	1 to 4
Agricultural training	*AGRI_TRAIN*	0.44	1.13	0 or 1
Social capital indicators				
Belong to a Protected Designation of Origin	*ORIGIN_DESIG*	0.22	1.91	0 or 1
Belong to an Irrigation District	*IRRI_DISTRICT*	0.33	1.44	0 or 1
Belong to a Farmers' Union	*FARM_UNION*	0.30	1.52	0 or 1
Farm characteristics				
Number of olive grove plots	*FARM_NUM*	7.70	0.95	1 to 60
Olive grove area	*FARM_AREA*	17.88	1.60	Ha
Number of olive varieties	*VARIETIE_NUM*	1.97	0.52	1 to 5
Plantation age	*OLIVE_AGE*	104.67	1.05	Years
Density of plantation	*DENSITY*	97.43	0.26	Trees / ha
Average annual output	*OUTPUT_AVE*	5,274.14	0.36	Kg / ha
Farm profitability	*FARM_PROFIT*	1,603.18	0.66	€ / ha
Farm Management				
Main-activity farmer	*FARMER_MAIN*	0.60	0.80	0 or 1
Family labour force	*FAMILY_LABO*	4.53	1.38	Man-days labour / ha
Declares that he/she devotes more than 50% of their time to agriculture	*SPEND_50*	0.44	1.13	0 or 1
Outsources some growing tasks	*OUT_WORK*	0.27	1.64	0 or 1
Technical fertilisation method	*TECHNI_FERTI*	0.31	1.51	0 or 1
Set Schedule for phytosanitary treatment	*FIX_SHEDULE*	0.34	1.38	0 or 1
Olive tree-trunk vibrator	*TRUNK_VIBRA*	0.27	1.64	0 or 1

[10] The agricultural districts, known as *comarcas agrarias*, are areas with homogeneous edaphoclimatic conditions and similar agricultural land use. In Andalusia, each district covers approximately 1,700 square kilometres.

The variable representing the level of education (1: no education; 2: primary education; 3: secondary education; 4: university education) is highly correlated with the agricultural training variable (Cramer's V = 0.263***) that was finally selected for the model. Similarly, there is also a high degree of collinearity (Pearson's R = 0.908***) between the productive performance and olive grove profitability variables. In this case, we finally decided to include the latter in the model.

3.2. Econometric Approach

The Multivariate Probit model (MVP) uses a simultaneous equation system that models the influence of the set of explanatory variables on each of the different SCP. In this framework, the decision to adopt one practice is like to be correlated to other soil conservation management decisions. In contrast to the Univariate Probit model (UVP), the MVP model takes into account the potential correlation among the unobserved disturbances in the adoption equations as well as the relationship between the adoption of different SCP[11]. The correlation between SCP indicates either complementarity (positive correlation) or substitutability (negative correlation). Failure to capture unobserved factors and inter-relationships among adoption decisions regarding different practices will lead to bias and inefficient estimates (Kassie *et al*., 2009). Readers are referred to Chib and Greenber (1998) for further discussion of this subject. The general specification of an MVP model is (Greene, 2007):

$$y^*_{im} = B'_m x_{im} + \varepsilon_{im},\ (m = 1,..., \text{M}) \qquad (1)$$

$$y_{im} = 1 \text{ if } y^*_{im} > 0 \text{ and 0 otherwise} \qquad (2)$$

whereby, in our case, *m*=1,2,3 denoting the three types of SCP. In Equation (1) the assumption is that a rational i^{th} farmer has a latent variable, y^*_{im}, which captures the unobserved preferences or demand associated with the m^{th} choice of SCP. This latent variable is assumed to be a linear combination of observed characteristics (see Table 1) that affect the adoption of *m* SCP, x_{im}, as well as unobserved characteristics captured by the stochastic error term ε_{im} (Kassie *et al*., 2009). The parameter vector to be estimated is denoted by B'_m. The exact measurement of response strengths y^*_{im} has a latent nature and its information regarding the adoption of a particular SCP is given by an observed dichotomous vector y_{im} (2).

As the variance-covariance matrix of ε_{im} in equations (1) includes potentially non-zero correlation off the main diagonal, the ε_{im} jointly follows a multivariate normal (MVN) distribution:

$$(\varepsilon_{i1,}\varepsilon_{i2,}\varepsilon_{i3})' \sim MVN\left(0, \begin{bmatrix} 1 & \rho_{12} & \rho_{13} \\ \rho_{12} & 1 & \rho_{23} \\ \rho_{13} & \rho_{23} & 1 \end{bmatrix}\right) \qquad (3)$$

where ρ_{jm} is the correlation coefficient of ε_j and ε_m for $j \neq m$ (3). This trivariate probit (MVP) framework allows for increased efficiency in parameter estimation in the case when SCP are assumed to be related to each other. A Simulated Maximum Likelihood approach (SML) is used to estimate the MVP. The probabilities that enter the log likelihood, its derivatives and so on are computed using the Geweke-Hajivassiliou-Keane (GHK) simulation method in Limdep 9.0 (Greene, 2007). The approximation is based on averaging R draws form a certain multivariate normal distribution, for each observation (increasing R brings a greater accuracy[12]).

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[11] This econometrical approach is similar to the Seemingly Unrelated Regression Equations (SURE) model with the particular feature that the dependent variables are binary.
[12] In the simulations we use 200 random draws.

4. Results and Discussion

Table 2 shows the variables that were significant after filtering for each of the SCP. In order to determine which variables were considered indicators of the adoption of SCP, Wald tests were performed interactively. Furthermore, we tested for the emergence of possible problems of multicollinearity using auxiliary linear regressions with the independent variables of each of the three equations relating to the adoption of SCP. The Variance Inflation Factors (VIF < 1.2), Condition Indices (CI < 7) and the Variance-decomposition Proportions (VP < 0.5) indicated no problems with multicollinearity bias.

As can be observed in Table 2, the Wald test suggests our model is significant ($\chi^2_{(14)}$ =83.342***). Hence, the inclusion of the parameters of interest results in a statistically significant improvement in the model fit.

Table 2. Trivariate probit model of soil conservation practice adoption

Variable	No burning olive-desuckering debris (*NBODD)*		Shredded olive-pruning debris as soil cover (*SOPD)*		Cover crops under mower control (*CCMC)*	
	B_1	SE_1	B_2	SE_2	B_3	SE_3
Sociodemographics						
AGRI_TRAIN	--		--		0.522**	(0.213)
CHILDREN	--		--		0.570**	(0.283)
Farm Characteristics						
FARM_AREA	0.006*	(0.004)	--		0.009**	(0.004)
FARM_PROFIT	--		0.221**	(0.094)	0.448***	(0.112)
Farm Management						
FARMER_MAIN	--		0.356**	(0.167)	--	
SPEND_50	--		--		0.449*	(0.235)
FAMILY_LABO	-0.032*	(0.018)	--		--	
TECHNI_FERTI	0.551***	(0.194)	0.404**	(0.194)	--	
Social Capital						
IRRIGA_DISTRICT	0.384**	(0.190)	0.357*	(0.193)	--	
DESIGNA_ORIGIN	--		--		0.756***	(0.255)
Constant	-0.687***	(0.213)	-0.905***	(0.281)	-2.671***	(0.382)
Wald $\chi^2_{(14)}$	83.342***					
Log pseudo-likelihood	-380.284					
Replications	200					
Number of observations	232					

Note: ***; **; * indicates the parameter is significant at the 0.01, 0.05 and 0.1 level respectively.

Meanwhile, Table 3 performs a Likelihood Ratio (LR) test considering three univariate probit models in contrast to a trivariate solution. The LR test is significant ($\chi^2_{(3)}$ =52.752***), suggesting the joint significance of the error correlations, implying that using a MVP model is more efficient than using an UVP model (H_0 is rejected). This result is consistent with significance of error correlation coefficients (rho) between SCP (Table 3) supporting the econometric assumption that the choice of SCP are not independent of each other. More specifically, rho reflects "the correlation between the outcomes after the influence of the included factors is accounted for" (Greene, 2007).

In this regard, a relationship of interdependence emerges from lesser to greater technical specialisation between *NBODD* and *SOPD* and between *SOPD* and *CCMC*. More specifically, there is a relationship of sequential dependence according to the technical complexity of the practice. Thus, the positive rho coefficients are pointing to the existence of synergies and complementarities among these farming practices[13]. Notwithstanding, it has to be pointed out that the correlation coefficient (ρ_{13}) between *NBODD* and *CCMC* is not significant, perhaps due to the fact that the first practice does not require a high degree of innovation and specialisation, unlike the second case. Therefore, we cannot confirm the existence of a significant degree of complementarity between these two farming practices.

Table 3. Correlation coefficients of soil conservation practice adoption equations

Equations		ρ	SE
No burning olive-desuckering debris Shredded olive-pruning debris as soil cover	ρ_{12}	0.623***	0.082
No burning olive-desuckering debris Cover crops under mower control	ρ_{13}	0.150^{ns}	0.135
Shredded olive-pruning debris as soil cover Cover crops under mower control	ρ_{23}	0.329***	0.126
Likelihood ratio test (-2 [$\|LL_0\|$-$\|LL_1\|$]) of $\rho_{12} = \rho_{13} = \rho_{23} = 0$ (H_0); $\chi^2_{(3)}$ = 52.752***			

Note: *** indicates the correlation is significant at the 0.01 level; ns indicates the correlation is not significant.

In aggregate terms, we can see how the adoption of SCP is influenced by factors related to farmers' socio-demographic profile, social capital, physical and financial aspects of the olive grove as well as how it is managed. However, it must be said that the factors that determine the probability of adopting each SCP are highly heterogeneous.

As can be observed, farmers' socio-demographic profile only affects the adoption of *CCMC*. In this sense, having agricultural training increases the likelihood of adopting this soil management technique, as it requires a high level of specialisation, although its impact on the profitability of the olive grove in the short-term is not exempt of uncertainty. In this sense, it is not surprising that agricultural training is important to understand environmental implications and the fact that the olive grove will be more profitable in the long term if management techniques employing plant cover to protect the soil are adopted. Pioneer research such as Rahm and Huffman (1984), Miranowski and Shortle (1986) and Norris and Batie (1987) have already highlighted the existence of a positive relationship between the level of agricultural training and the decision to adopt conservation agriculture (Bielders et al., 2003).

Likewise, if the olive grower has descendants, the likelihood of adopting *CCMC* increases, due to the possibility of the olive grove passing to a new generation. Moreover, the possibility of a generation change-over may encourage long-term decision making aimed at leaving children the legacy of a productive, well managed and environmentally friendly olive grove. In Spain, Calatava-Leyva et al. (2007) found evidence of the importance of a generation change-over in the adoption of SCP precisely in the case of olive groves.

With respect to farm characteristics, surface area is an indicator of the adoption of *NBODD* and *CCMC*. In this sense, an increase in the surface area of an olive grove implies an increase in the likelihood of adoption, as reported by Smit and Smithers (1992), Feder and Umali (1993), Fuglie (1999) and Calatrava-Leyva et al. (2007). In this sense, having a medium-sized to large olive growing operation can encourage the search for technological innovations, which is why this factor plays an important role in the adoption of CCMC. Similarly, the more profitable an olive grove is, the greater the probability of SCP adoption with a high level of specialisation, such as SOPD and CCMC, as shown by Gould et al. (1989), Saltiel et al. (1994) and Calatrava-Leyva et al. (2007). The mean group comparisons (non-parametric Mann-Whitney U test) support this point: in the case of SOPD, the SCP adopter recorded a mean of €1,785/ha compared to €1,416/ha for non-adopters (U=5448.5**, z=-2.50). For CCMC, the difference is even more apparent: €2,045/ha and €1,445/ha, respectively (U=3541.5***, z=3.72). In the case of NBODD (€1,702/ha and €1,540/ha), the mean difference between groups was not statiscally significant.

[13] The existence of unobservable factors such as farmers' managerial ability could be another potential explanation.

Finally, regarding the variables related to farm management, the factors that determine the adoption of the various SCP are once again highly heterogeneous. In the first place, *FARMER_MAIN* is positively correlated with the adoption of *SOPD*. In contrast, the variable representing the time devoted to agriculture (*SPEND_50*) is a better predictor of the adoption of *CCMC*. Therefore, having agriculture as their main activity or devoting a large percentage of time to it increases the likelihood of adoption. Devoting time to managing the olive grove implies a greater probability of accessing information related to the sector that will influence subsequent decision making. In Spain, Calatrava-Leyva et al. (2007) find this aspect to be decisive for the adoption of contour ploughing.

Furthermore, family labour input in the olive grove registers an inverse relationship with the adoption of *NBODD*, that is, the likelihood of burning olive-desuckering debris increases when more family labour is employed in the olive grove. In addition, these farms are more often family-run and therefore more prone to traditional management techniques, including the burning of debris. In relation to fertilisation, we found a positive correlation between the use of a technical fertilisation method and SCP adoption. Other studies have highlighted how the prior adoption of innovations is related positively to the adoption of SCP (Rahm and Huffman, 1984; Nielsen et al., 1989; Caswell et al., 2001; Calatrava-Leyva et al., 2007).

Finally, the variables that represent social capital reveal their importance in explaining the adoption of SCP. As can be observed in Table 3, the fact that a farmer belongs to an irrigation community increases the likelihood of adopting *NBODD* and *SOPD*. However, in the case of practices that require a higher level of specialisation, such as *CCMC*, belonging to the Regulating Authority of a Protected Designation of Origin (PDO) plays a key role in the adoption process. This heterogeneity could be due to the larger size of PDOs compared to irrigation communities, as well as their purpose, as PDOs tend to promote more sustainable production systems. Nevertheless, both organisations allow farmers to gain access to more information and share experiences that soften their initial reluctance to innovate. The main obstacle is that the cost of the SCP usually exceeds the profits in the short term, despite yielding long-term benefits. In this sense, many olive growers possibly imitate others when they adopt sustainable practices that require an increasing degree of specialisation. Authors such as Cramb (2005), Warriner and Moul (1992) and Swinton (2000) highlight the marked impact of growth in social capital on the adoption of SCP.

5. Conclusions

As suggested by numerous studies (Feder and Umali, 1993; Knowler and Bradshaw, 2007 and Prager and Posthumus, 2010 for example), the heterogeneity of the factors that explain the extent to which soil conservation practices are adopted can be attributed, among other things, to the diversity of cultural environments, the specificity of agricultural systems (in the case of olive groves, slopes play an essential role), methodological approaches, etc.

The results obtained in the study support this aspect, showing a positive correlation between SCP adoption and socioeconomic variables (farmers' agricultural training and existence of descendants), structural characteristics of the farm (size and profitability), type of farm management (time devoted to the farm and the use of a technical method of fertilisation) and social capital indicators, the latter being a key aspect of the overall adoption of soil conservation practices. However, depending on the management difficulty of the conservation technique, differences are detected in relation to the type of organisation the olive grower belongs to. In the case of complex techniques, such as the implementation of plant cover, Protected Designations of Origin are the best disseminators. In contrast, the least technologically complex practices, such as not burning olive-desuckering debris and shredding olive-pruning debris, are adopted to a greater extent by olive growers that are members of Irrigation Communities.

Considering the positive impact of plant covers managed by weeding on the agro-ecosystem, there is a great deal of room for improvement. As a result, policies should aim to clarify any doubts that olive growers may still have regarding the reduction in the profitability of the crop. In this sense, as indicated in other studies (Parra et al., 2007; Calatrava and Franco-Martínez, 2011), direct interaction and communication between farmers is the main driving force behind the adoption of technological innovations in farming. Therefore, agricultural policies aimed at encouraging the implementation of soil conservation techniques should take into account the vital role played by social capital in olive groves in Andalusia. In this sense, from a public policy perspective, information should be channelled and human capital promoted through training by using the framework of social capital that farmers are a part of and that they use to interact. This strategy reduces the cost of implementing policies and also contributes to their success, as the farmers themselves are part of it and, therefore, give more credibility to sharing experiences in managing their farms. This could be the reason why the impact of other agents such as farmer unions, whose guidelines are often top-to-bottom, have not turned out to be early indicators of adoption.

The transfer of the results obtained to the sector and above all to the administration could encourage the adoption of institutional innovations that, as mentioned previously, should be channelled through the framework of social capital in which farmers interact. This would lead to the achievement of the post-2013 CAP goals, the social justification of which is to bridge the gap that exists between research and the transfer of that knowledge to the agricultural sector. In this sense, the new research-knowledge transfer approach of the CAP with the creation of the European Agency for Agricultural Innovation, which will be carried out by the Operating Groups, could be a very important pillar for the transfer of innovations as they involve all the interested parties. Within these structures, special importance is given to farmers, which could be a way of bringing innovations closer to the agricultural sector through promoting social and human capital, as highlighted by the policy implications of this research. In this sense, the CAP post 2013 should stress the importance of adapting soil conservation programmes to regional characteristics following a down-to-top approach in order to take into account farmers' attitudes towards adoption.

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