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Matching supply-side and demand-side analyses for the assessment of agri-environmental schemes: The case of irrigated olive groves of southern Spain

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Abstract.

Agri-environmental schemes (AES) in irrigated olive groves (IOG) in southern Spain are assessed using a double analysis from the supply and demand side. Regarding the supply-side analysis, a choice experiment is used to assess farmers' preferences toward AES, including some innovative issues, such as uptake in irrigated permanent crops, ecological focus areas and collective participation. With regard to the demand-side analysis, secondary sources of information are used to explore gains obtained from the implementation of such schemes in IOG. Results indicate that only the implementation of the most stringent AES scenarios could provide positive net social welfare gains and a priori only these scenarios should be considered for implementation by policy-makers. However, the implementation of these most stringent AES would only result in very low net social welfare gains. Further research is required to provide more accurate estimates of such gains and replicate this assessment in other agricultural systems.

Keywords: Agri-environmental schemes, intensive agricultural systems, public goods, choice experiment, net social welfare gains.

JEL codes: Q18, Q58.

1. Introduction

The provision of public goods (PGs) by agriculture is a relevant objective common to most agricultural policies of developed countries. This objective has become increasingly relevant over time because of society's increasing demand for such goods. However, the design of efficient instruments to achieve this objective represents a daunting challenge for policy-making. In particular, policy-makers have to take account of the type of joint production and farmers' preferences and circumstances to design instruments that effectively encourage agricultural PGs production without distorting commodity markets (OECD, 2001; Cooper et al., 2009). Yet, analysis is still required to support public decision-making regarding the design of such instruments (Hart et al., 2011).

Among instruments to encourage the provision of PGs by agriculture, voluntary incentive-based payments aimed at compensating the farmer for the income forgone resulting from the use of non-productive agricultural practices are a suitable option (OECD, 2001; Hart et al., 2011; Hodge, 2013). These are no (or few) distorting instruments (i.e., included within the Green Box of World Trade Organization Agreement on Agriculture) specifically targeted at the production of agricultural PGs. A paradigm case of this type of instrument is the agri-environmental schemes (AES) of the Common Agricultural Policy (CAP) of the European Union (EU). AES are multiannual and voluntary incentive-based payments to farmers for preserving and enhancing environmental PGs. They usually consist of a per-hectare payment implemented regionally and co-financed by the EU and each of its Member States in exchange for the implementation of certain environmentally-friendly practices (Espinosa-Goded et al., 2010; Uthes and Matzdorf, 2013). AES stand out as one of the most significant CAP instruments as they have assigned an aggregated expenditure of €22.2 billion (that is, 22% of the EU's Rural Development Policy 2007-2013 budget, according to ECA, 2011).

AES have been the subject of much attention by researchers (Siebert et al., 2006; Uthes and Matzdorf, 2013). Their work has focused mainly on the barriers to participation in such schemes (Falconer, 2000; Christensen et al., 2011; Broch and Vedel, 2012), and on improving their design (Ruto and Garrod, 2009; Espinosa-Goded et al., 2010; Matzdorf and Lorenz, 2010). Yet, there are still some broad issues that deserve further research. Firstly, specialized literature usually fails to compare supply and demand-side analysis, the main reason being that this type of comparison is commonly both time and resource demanding. Second, AES implementation both in permanent crops and irrigated agricultural systems has been little studied in the literature. The relevance of this from a policy perspective is that production of environmental PGs differs significantly among agricultural systems (Cooper et al., 2009), especially between arable and permanent crops or between rain-fed and irrigated systems. Depending on the agricultural system in question, therefore, different implications can be expected with regard to the implementation of AES. Furthermore, researchers' limited focus on AES in irrigated and/or permanent crops contrasts with the abundant literature about AES in rain-fed arable and grassland systems (a comprehensive survey is included in Uthes and Matzdorf, 2013).

In this paper, a double analysis from the supply and demand side is carried out to better understand the costs and benefits related to the implementation of AES. Regarding the supply-side analysis, a choice experiment is used to assess farmers' preferences toward AES, including some innovative issues, such as uptake in irrigated permanent crops, ecological focus areas (EFA) and collective participation. As case study we use the irrigated olive grove system (IOG) in Andalusia (southern Spain). With regard to the demand-side analysis, it is based on earlier works that estimate the economic value of environmentally-friendly practices in Andalusian olive growing. The main objective of this double-sided analysis is to support the design of a new AES targeted at promoting PG production by IOG, and to partially bridge the existing knowledge gaps about the inclusion of EFA and collective participation in AES contracts. This paper is strongly policy oriented and aims to identify good policy options for promoting agricultural PGs, and is therefore useful for policy-making, particularly nowadays, when the national and regional Rural Development Programs (2014-2020) are being designed. The paper has therefore been structured as follows. The next section explains the innovative issues aforementioned. This is followed by a description of the method used and the data gathering. The main results regarding the supply-side analysis are presented and discussed in the fourth section while those regarding demand-side analysis are presented and discussed in the fifth. The sixth section outlines the main policy implications.

2. The context of irrigated olive groves system and new issues in agri-environmental policy

As mentioned in the introduction, this paper analyzes AES that include several issues that have not been widely explored in the specialized literature. Firstly, it analyzes AES in an *irrigated permanent crop* such as IOG. This agricultural system is widespread in southern Europe and merits analysis of its specific AES design. The analysis of AES for IOG is particularly opportune not only due to their high socio-economic significance, but also because of the numerous environmental issues that have emerged because of the expansion and intensification of olive growing over the past two decades (Gómez-Limón and Arriaza, 2011). These negative environmental impacts are soil erosion, biodiversity loss, over-exploitation of water resources, non-point water pollution and deterioration of traditional landscapes. Indeed, recent studies (such as Carmona-Torres et al., 2014, or Villanueva et al., 2014) highlight that there is a great scope for improving the production of environmental PG by IOG. In particular, Villanueva et al. (2014) found that soil fertility, visual quality of the landscape, biodiversity and contribution to fighting climate change are the four PGs with the greatest potential for improvement from a supply perspective. Moreover, all of these PGs are in high demand in European (EC, 2010) and Andalusian (Rodríguez-Entrena et al., 2012) societies. Thus, it is reasonable that any AES for IOG should focus on agronomic practices aimed at increasing the provision of these PGs.

Secondly, this paper analyzes the inclusion of *ecological focus areas* (EFA) in AES. EFA is defined in CAP regulations as areas with landscape features, terraces, buffer strips, land lying fallow, afforested areas and agro-forestry areas, or areas with a reduced use of inputs on the farm, such as those covered by catch crops and winter green cover. The presence of EFA generally improves biodiversity, as well as other PGs such as visual quality of landscapes, soil conservation, and so on (Stoate et al., 2009; EC, 2011a). This is the main reason that led the European Commission (EC, 2011b) to propose a new instrument in the CAP 2014-2020, known as *green payment*, for those farms fulfilling some basic environmental requirements, including dedicating 7% of their farmland to EFA. However, this particular requirement was relaxed as a result of the political debate about the share of EFA, and in the final regulation (Regulation 1307/2013, Art. 43-47) this share was set at 5% for arable land only (permanent crops are eligible for this payment without any minimum EFA requisite). In this regard it is worth pointing out that choosing EFA as an attribute of proposed AES has not been analyzed elsewhere, although this is an interesting issue that would require further study if it were to be considered for a future implementation of green payment in permanent crops, as initially proposed by the European Commission.

Thirdly, *collective participation* (COLLE) in AES, where farmers collectively sign AES contracts, is also studied in this analysis. Collective contracts represent a promising way of reducing transaction costs (mainly public) while increasing the environmental effectiveness of policy instruments. Specifically, increasing collective participation in AES reduces the number of applications to be processed as well as the costs of monitoring, consequently reducing the transaction costs incurred by the government (Franks, 2011; Emery and Franks, 2012). Moreover, if the collective participation in AES is implemented in such a way that ensures the proximity of the farms that form the collective, a greater environmental effect would also be expected (Sutherland et al., 2012). To the authors' knowledge, no papers analyze farmers' willingness to participate in AES collectively in agricultural systems and regions other than arable lands and/or pastures and Northern-Central Europe respectively, nor provide quantitative estimates of willingness to accept (WTA) collective AES. Quantitative estimates of WTA to set possible bonuses for collective participation in AES and insights in other regions (e.g., the Mediterranean) and for other types of agricultural systems (e.g., irrigated permanent crops) are therefore required.

3. Method to assess farmers' preferences toward agri-environmental schemes

3.1. Choice experiment approach

The choice experiment method (CE) is a stated preference valuation technique based on Lancasterian Consumer Theory of utility maximization which postulates that consumption decisions are determined by the utility or value derived from the attributes of the good being consumed (Lancaster, 1966). The econometric basis of the approach is the random utility theory (McFadden, 1974). For an extensive explanation of the CE theory and practice, see Hensher et al. (2005). In particular, CE is well suited to measuring the marginal value of the attributes of a good or policy (Ruto and Garrod, 2009). In the case of the latter (i.e., attributes of a certain policy such as AES), the underlying assumption is that farmers' choices among subsidy schemes depend on the specific characteristics of subsidy schemes (Christensen et al., 2011). The increasing use of this method in recent specialized literature (Ruto and Garrod, 2009; Espinosa-Goded et al., 2010; Christensen et al., 2011; Broch and Vedel, 2012; Schulz et al., 2014) indicates its usefulness and validity for analyzing farmers' preferences toward policy measures, in particular AES. This is therefore the methodological approach chosen for this analysis.

3.2. Attributes and levels

Six attributes were used in the CE. Three of them are linked to agricultural management (two of them related to soil conservation practices and one to EFA), two policy design attributes and a payment attribute (see Table 1).

Among the agricultural attributes, the two related to soil conservation practices focus on the use of cover crops (CC), since it represents the most useful agricultural practice in olive growing in terms of enhancing the production of environmental public goods (Villanueva et al. 2014). Thus, the area covered by CC and its management are the two related attributes included in the CE. For the attribute *Cover crops area* (CCAR), two levels were set at 25% and 50% of the olive grove area (CCAR-25% and CCAR-50%, respectively) (see Table 1). As regards the attribute *Cover crops management* (CCMA), two levels were considered: free (CCMA-Free) and restrictive management (CCMA-Restr). The latter corresponds to the management established in the current AES that is specifically dedicated to olive growing (*Sub-measure 7* or SM7), which basically restricts the use of both tillage and herbicide in CC management, while the former implies no restrictions other than those that are part of cross-compliance. A more detailed description of the method can be found in Villanueva et al. (2015).

For the attribute *Ecological focus areas* (EFA), levels were set at 0 and 2% of the olive grove plots covered by EFA (EFA-0% and EFA-2%, respectively). The first level is equivalent to current eligibility requirements for the Common Agricultural Policy (CAP) 'green payment' in permanent crops. The second is below 5% of EFA finally established for arable land in the new CAP and decided upon after taking into account both the current lack of these kind of areas in Andalusian olive groves and the difficulties of increasing the share of EFA in permanent crops (Gómez-Limón and Arriaza 2011).

Table 1 about here

Collective participation and monitoring levels are the two design attributes included in the CE. For *Collective participation* (COLLE), the two established levels are collective and individual participation. For participation to be considered collective, a group of at least five farmers whose farms were located in the same municipality have to sign the same AES contract. Regarding the attribute *Monitoring* (MONI), two levels were also set at 5 and 20% (MONI-5% and MONI-20%, respectively). The lower level was equal to the normal monitoring level of CAP measures, while the higher makes a visible difference to the farmers.

Finally, with regard to the *payment* attribute (PAYM), four levels were set according to payments in SM7 (€204-286/ha per year). Two levels (€200/ha and €300/ha) were set in line with these payments, while two further levels (€100/ha and €400/ha) were set as minimum and maximum payments.

3.3. Experimental design and data collection

Considering the number of attributes and levels, a large number of AES profiles (128) can be constructed, resulting in 1924 combinations for a two-option choice set design. To create a more manageable number of options, the fractional factorial design and optimal orthogonal in the differences proposed by Street and Burgess (2007) was used, resulting in 192 profiles and a D-efficiency of 91.3%. This design is prepared to include possible interactions between attributes. To make the number of choice tasks manageable for respondents, the 192 choice sets were divided into 24 blocks of 8 choice-sets each, with one farmer answering one block. In each choice set, farmers were asked to choose between two alternatives, in addition to a possible no-choice (Status Quo or SQ) option under which farmers choose to continue with their current practice.

A multi-stage procedure was employed for sampling. In the first stage, five Andalusian agricultural districts[1] in the DHG were selected from a total of 52, using a proportional random procedure according to olive grove surface area. This sample of districts covers 453,682 ha and accounts for 31.0% of the Andalusian olive groves. In the next stage of the procedure, at least 60 personal interviews were conducted per district using random route sampling, as a result of which 330 properly completed questionnaires were obtained, 117 for IOG. Among the latter, 13 were considered to be protests[2], reducing the total number of valid interviews to 104, that is to say, 832 choices. Interviews were carried out from October 2013 to January 2014. A cheap talk was used to ensure that farmers understood correctly before answering the questionnaire.

3.4. Model specification: Random parameter logit model

In the CE method, until recently, the most commonly used discrete choice model for the analysis was the multinomial logit model (MNL). Despite its relative simplicity, MNL has some significant limitations which can lead to unrealistic predictions, the most important being the consideration of homogeneous respondents' preferences and its related assumption of the independence of irrelevant alternatives (IIA) (Hausman and McFadden, 1984). To overcome these limitations, more flexible alternatives have been developed such as mixed logit models, among which Random Parameter Logit (RPL) model is one of the most commonly used. The RPL is a model in which an individual's utility from any alternative in the choice set includes a stochastic part that may be correlated over alternatives and that may be heteroskedastic (Hensher et al., 2005). By including this stochastic term, preference heterogeneity is directly incorporated through individuals' random taste variations and correlation across choice sets and alternatives can be incorporated. The RPL approach has

[1] Campiña Norte and La Loma (province of Jaen), La Sierra and Campiña Alta (province of Cordoba), and Norte (province of Malaga).

[2] Those who chose the SQ-option in all the choice sets without considering the alternative AES proposed in each (i.e., did not make trade-offs among alternatives but directly chose the SQ-option) were considered protests. The most commonly cited reason for always choosing the SQ-option was lack of trust in public institutions. This definition of protesters has also been used in previous works (e.g., Christensen et al., 2011).

proven to be very effective in a number of studies, especially when evaluating environmental PGs (Scarpa and Thiene, 2005; Rodríguez-Entrena et al., 2012), and particularly for the evaluation of agri-environmental policies (Ruto and Garrod, 2009; Espinosa-Goded et al., 2010; Christensen et al., 2011; Broch and Vedel, 2012). These studies attest to the usefulness of this approach when analyzing heterogeneity, hence it is the approach used here.

Here a specific version of the RPL, the Error Component RPL (EC_RPL) has been used. EC_RPL introduces an additional random error component that makes it possible to account for potential correlation over utilities from different alternatives (Scarpa and Thiene, 2005). In this model, the utility function associated with each of the alternatives can be expressed as follows:

$$U_{Alt\ A} = \beta'\chi + \beta_s'\chi + \eta_{No\ SQ} + \varepsilon \quad [1]$$

$$U_{Alt\ B} = \beta'\chi + \beta_s'\chi + \eta_{No\ SQ} + \varepsilon \quad [2]$$

$$U_{SQ} = ASC_{SQ} + \beta'\chi + \beta_s'\chi + \gamma S + \varepsilon \quad [3]$$

where ASC_{SQ} is the alternative-specific constant for the status quo choice, χ is a vector representing the attributes and $\eta_{No\ SQ}$ is the error component that induces the correlation between the non SQ alternatives, assumed normal distribution [$\eta_{No\ SQ} \backsim$ N $(0, \sigma^2)$]. The vector of coefficients (β) reflects individual preferences and is randomly distributed in the population following a density function $f(\beta_n \mid \theta)$, where θ is the distribution parameters. β_S represents heterogeneity associated with individual (farm and/or farmer) characteristics. γS captures heterogeneity in preferences toward choosing the SQ option explicated by a set of individual characteristics. All random error terms (ε) follow a Gumbel distribution and have been assumed to be constant among the different choices made by each individual. Choices are modelled following a panel structure, thus the integer probability involving a product of logit formulae (Train, 2003). The joint probability of respondent n choosing alternative i on each of the T choice situations is given by:

$$P[t(n)] = \int_\beta \int_\eta \prod_{t=1}^{T} \frac{\exp\left(\lambda(\beta_n'\chi_{ti} + \eta_{in})\right)}{\sum_{j\subset A_t}\left(\lambda(\beta_n'\chi_{ti} + \eta_{jn})\right)} f(\beta_n|\theta)\, d\beta \cdot \varphi(0, \sigma^2)\, d\,\eta_{jn} \quad [4]$$

where A_t= ($Alt\ A$, $Alt\ B$, SQ) is the choice set, λ is a scale parameter, $f(\beta_n \mid \theta)$ is the density of the attributes random parameters, and $\varphi(\cdot)$ is the normal density of the error component (η_j) which equals zero when j = SQ. This equation cannot be evaluated analytically because the choice probability does not have a closed form. Hence it is approximated using simulation methods, using 200 Halton draws in the current analysis. In RPL, the analyst has to assume random and non-random parameters and, in the case of the former, he/she assumes their distribution as well. In the present model, all attributes are assumed to follow a normal distribution, except for PAYM and MONI which are assumed to be non-random.

To capture heterogeneity in farmers' preferences, interactions between the attributes and socio-economic characteristics as well as between the ASC_{SQ} have been used. The process of identifying those characteristics that significantly determine farmers' choice in the CE was carried out in stages. Firstly, it was looked for significant individual interactions between attributes and socio-economic characteristics (obtaining one EC_RPL model for each interaction). More than 200 different models were generated. Secondly, observing the results obtained from the previous step, different significant interactions were simultaneously included in the model to observe the robustness of the relations and to confirm whether they continue to be significant when other interactions are also considered. This step resulted in a 4-interaction EC_RPL model. The 4 interactions considered are:

- CCAR×GROUNDHARV, which represents the interaction between the CCAR attribute and the share of olives harvested from the ground;
- CCMA×EDUCA2, which represents the interaction between the CCMA attribute and the dichotomous variable of secondary education (scoring 1 if the farmer attended secondary school or higher);
- EFA×NO-TRAINING, which represents the interaction between the EFA attribute and the dichotomous variable of agricultural professional training (scoring 1 if the farmer has undergone professional training);
- COLLE×NO-TAKEOVER, which represents the interaction between the COLLE attribute and the dichotomous variable of farmers' perception about farm takeover (scoring 1 if the farmer thinks there will not be farm takeover).

Finally, two more interactions between the ASC_{SQ} and socio-economic characteristics where added to the 4-interactions EC_RPL model mentioned above. In this regard, two characteristics were considered: Oliarea20, which represents farm size (scoring 1 when the olive grove area is less than 20 ha); and SinglePaym750, which represents farm payments received through single payment (scoring 1 when the average single payment to the farm is higher than €750/ha per year).

3.5. Farmers' welfare analysis

In CEs, the coefficient of the monetary attribute is interpreted as an estimate of the marginal utility of income. Using a linear utility function, model coefficients can therefore be used to provide welfare estimates for changes in attribute levels. Thus, marginal rates of substitution between non-monetary and the monetary attribute are estimated by calculating the ratio of the coefficient of the former to the negative of the coefficient of the latter. These are also called the “implicit prices”, representing the WTA for a 1% or 1 unit increase in the quantity of the attribute in question if quantitative (e.g., area of EFA), or for a discrete change in the attribute (e.g., from free to restrictive CCMA) if qualitative. Additionally, observed welfare changes between alternatives that imply different combinations of attributes can be estimated. These welfare changes can be measured using the compensating variation or surplus (CS) formula described by Hanemann (1984):

$$CS = -\frac{(U_0 - U_1)}{\beta_P} \quad [5]$$

where β_P is the parameter estimate of the monetary attribute (PAYM or payment received), and U_0 and U_1 represent the farmers’ utility before and after the change.

4. Supply-side approach: Results and discussion

4.1. Description of surveyed farmers

The farms surveyed are mainly located in Jaen and, to a lesser extent, in Cordoba and Malaga. Their average olive grove area is 24.4 ha, which is roughly on par with those reported by Gómez-Limón and Arriaza (2011), whose survey was, for the most part, carried out in the same agricultural districts. On average, the farms surveyed irrigate more than three-quarters of their olive groves. The age of the olive groves is around 60 years old and they have 137 olive trees/ha on average, with 2.4 stems/tree. The olive groves are primarily located on low-to-moderate slopes and 0.65% of their area is dedicated to EFA.

Most farmers surveyed use conventional olive–growing techniques (55.8%), while the vast majority of the remaining farmers use integrated techniques (42.3%). The use of CC is widespread (more than three-quarters of the farmers use CC), although in a low-to-moderate way (on average, 21.7% of the olive groves area devoted to CC). Actually, only 38.5% of the farmers use CC in over 25% of the olive grove plots. Other soil conservation practices such as adding shredded pruning debris to soil are also used by over half of the farmers (57.7%). These figures are consistent with previous works that highlight the increasing use of soil conservation practices in olive growing (Rodríguez-Entrena and Arriaza, 2013). With regard to irrigation, farmers surveyed use 909 m^3/ha·per year on average and the vast majority use localized irrigation systems (mainly drip irrigation). Two-thirds belong to water user associations, 58.7% use fertigation and half of them use groundwater whereas the other half uses surface water.

Yearly average yield of farmers surveyed is 6,352 kg of olives/ha. A considerable share of the yield (23.5% on average) is harvested from the ground (olives that fall directly onto the ground, usually harvested with blowers and sweepers). Average CAP single payment reported is €766/ha·per year. The figures are in line with those reported by Gómez-Limón and Arriaza (2011).

On average, the farmers surveyed are 48.5 years old. They allocate most of their time to farming (56.5%), their family usually depends on farm income (57.2% of the ratio farm income/family income) and their mean number of children is approximately 1.7. They usually have a secondary school leaving certificate, some have undergone professional training, and half of them ask for professional advice at least once a month. Only 16% of farmers take up AES in olive growing, 35% are aware of such AES and half of them are aware of cross-compliance requisites in olive growing. Around 40% of farmers think that there will not be a farm takeover. They agree that the use of CC both provides important environmental benefits (4.32 out of 5 points) and, to a lesser extent, is profitable to their farms in the long term (3.61 out of 5 points). Also, they agree that EFA provide important environmental benefits (3.86 out of 5 points). However, there is no clear trend in their perception of both CAP monitoring and farmers' compliance.

4.2. IOG farmers' preferences toward AES

The results of the EC_RPL are presented in Table 2. As can be observed, the model is highly significant and fits well, as shown by the main goodness-of-fit statistics (pseudo-R^2=0.441; LL=-496.5). Indeed, the analysis of preference heterogeneity of EC_RPL yielded a significant improvement in goodness-of-fit compared to that reported for MNL (pseudo-R^2=0.196; LL=-698.2). As can be observed in this table, all but one of the attributes are highly significant determinants of choice; all the coefficients show a statistical significance level of 5% or less (with the exception of MONI) and have the expected sign (negative coefficient for all of them except PAYM, reflecting farmers' disutility –or utility in case of PAYM). MONI is the attribute that received the least attention from farmers, indicating that the level of monitoring played a minor role in their choices.

Table 2 about here

The results of the EC_RPL show a high heterogeneity of farmers' preferences toward AES. Some points support this statement. Firstly, all standard deviations of the random parameters are significant, indicating that preferences vary significantly within the population.

Secondly, all the interaction parameters (socio-economic variables interacted with the attributes) are significant. This indicates that preferences across farmers toward each attribute vary as function of certain socio-economic characteristics of the farmers. For example, the interaction between the attribute EFA and the variable No-training (EFA×No-training) is both significant and negative, implying that a lack of professional training increases the disutility of farmers regarding EFA. Thirdly, covariates interacting with ASC_{SQ} (i.e., SinglePaym750 and Oliarea20) are also significant, reflecting the general farmers' willingness to uptake AES (that is, their willingness to choose AES alternatives instead of SQ) also depends on farms' characteristics. Finally, the fact that ASC_{SQ} is significant reflects unobserved heterogeneity that significantly explains farmers' preferences toward AES. These findings are in keeping with recent studies (Espinosa-Goded et al., 2010; Christensen et al., 2011; Broch and Vedel, 2012).

EC_RPL results of the attributes and their interactions can be better appreciated by observing Table 2, which shows general mean WTA estimates as well as mean WTA estimates for two farmers' profiles named as the most and the least willing to participate in AES (which represent WTA estimates including the full absence and the full presence of the interaction terms, depending on the sign of the coefficient). With regard to the attribute **CCAR**, mean IOG farmers' WTA is €6.2/ha per 1%-increase in CCAR. However, if the farmer does not harvest ground olives, such WTA falls to €2.8/ha (see *least-willing* farmer profile in Table 3). A significant negative interaction is found between the area used for CC and the share of ground olives over the total volume of olives harvested. The main reason for such an interaction is that, in general, farmers would not be willing to reach high levels of CCAR (e.g., those of the levels used in the CE, CCAR-25% and CCAR-50%) as it would make more difficult to harvest ground olives.

With regard to **CCMA**, results showed a moderately high WTA for this attribute (€115.2/ha). Thus, IOG farmers have a very negative perception of managing CC without tillage and with a very restrictive use of herbicides. This is in keeping with literature that highlights strong farmer preferences toward flexibility concerning farming requisites included in AES (Espinosa-Goded et al., 2010; Christensen et al., 2011). Yet, when farmers have at least a secondary-school education, their WTA falls (€66.5/ha), and the opposite is true when they do not have this level of education (€170.1/ha). The effect of the level of education on farmer's preferences toward AES has been widely observed in earlier literature (Siebert et al., 2006).

Table 3 about here

With regard to **EFA**, a WTA of €64.6/ha per 1%-increase of EFA in the olive grove area is valued on average for IOG. Agricultural training plays a role in farmers' preferences toward EFA given that when they undergo training, WTA falls to €45.9/ha, whereas WTA reaches €97.1/ha when they do not. Similarly, Rodríguez-Entrena and Arriaza (2013) also found a positive influence on the adoption of environmentally-friendly practices by trained olive growers. As expected, these estimates are notably above those of Schulz et al. (2014) for the use of EFA by German farmers in their arable land (with WTA of €9-51/ha). The main reason behind such a discrepancy in the WTA estimates seems to be the different types of agricultural systems analyzed: arable crops in the case of Schulz et al. (2014) and permanent crops in the present paper. Thus, implicit spatial restrictions related to permanent crops seem to have the effect of raising farmers' WTA (i.e., it is much easier to comply with EFA when you have no permanent cropping elements such as trees).

IOG farmers' WTA for **COLLE** is €124.5/ha on average. A specific source of heterogeneity related to this attribute has also been identified. Specifically, it is found that when farmers think there will be no farm takeover, they are more willing to participate in AES collectively and their WTA is reduced to €72.4/ha as a result (and the opposite is true, namely, their WTA increases to €160.1/ha if they think there will be farm takeover). The fact that farmers' decisions are influenced by the existence or not of a successor is well documented in existing literature (Wheeler et al., 2012). In the case of individual AES contracts, Ruto and Garrod (2009) found that farmers prefer not to encumber a successor with an AES contract they have negotiated. In the particular case of collective participation, this finding appears to be remarkably important, as collective participation requires mutual trust between the farmers involved. So, when an individual farmer decides to participate in AES as part of a collective, he/she will do it with farmers who he/she trusts the most. Yet, the successor may or may not want to be part of this collective deal and, normally, the predecessor does not wish to force the successor to participate in the deal or oblige other farmers to accept the successor as a new member of the collective (other farmers of the collective may trust the predecessor but not the successor). As a result, farmers who think there will be a successor will be less willing to commit to other farmers to participate in AES as part of a collective.

Qualitative information about COLLE gathered from the interviews is worth outlining. Firstly, there is considerable farmer skepticism about collective participation, particularly its usefulness for enhancing environmental performance. This skepticism represents a barrier to such participation, since farmers need demonstrable benefits in order to facilitate collective involvement in AES (Emery and Franks, 2012). Secondly, but also related, they express concerns about the possible intrusion of other farmers into their farm management. It was frequently heard (regardless of whether they refuse collective participation or not) that it is nonsensical to have to monitor each others' farms by themselves, identifying it as an "unnecessary" source of conflict among farmers (who, more importantly, are also neighbors). This is in keeping with Franks (2011), who highlighted the avoidance of problems with other farmers as a barrier to collective participation. Thirdly, is the issue of the setting-up groups. In this respect, most of the farmers at first thought that producers' cooperatives could act as collective in the AES contract. While the interviewer clarified that they would be free to find the farmers they liked to form the group, they continued to think –and expressed as such– that the cooperative could have an active role in the creation of groups. In this case, it is clear that olive oil cooperatives could act as facilitators of group creation, as they usually give assistance to farmers in farm management and CAP bureaucracy. The use of facilitators has been pointed out in earlier specialized literature as a key to creating groups in collective/collaborative AES (Franks, 2011). Fourthly, the sanction system is crucial when it comes to farmers refusing or agreeing to collective participation. In the pre-test, a tougher sanction system was included, linking individual to collective compliance. Almost all farmers interviewed in the pre-test refused to participate collectively, primarily as they considered monetary punishment due to non-compliance by other farmers to be unfair. Thus, less stringent levels of sanctioning, such as the one finally used in the current analysis (i.e., non-monetary penalization resulting from the non-compliance of other farmers of the collective), led to fewer farmers refusing.

With respect to **MONI**, the main finding is that farmers are barely aware of it when it comes to choosing whether to participate in AES or not. This appears to be counterintuitive and contradicts literature on AES uptake. In fact, Broch and Vedel (2012) estimated farmers' WTA of €38/ha per 1% absolute increase in the level of monitoring in AES in Denmark. These results indicate different behavior of the farmers regarding preferences toward the level of monitoring in AES, thus calling for further research to understand to what extent significant disutility to higher levels of monitoring in AES can be expected. This future research could focus on the reasons behind this different behavior. In particular, the qualitative information collected during the survey suggests that two different reasons could explain such low WTA for high-level monitoring, namely the willingness to comply with the requisites (expecting "fair" monitoring) and the adoption of strategic behavior (i.e., not willing to comply but assuming that they would not be fully monitored).

It is also worth highlighting the results for **ASC_{SQ}**. Its coefficient is significantly different from zero, which indicates that, apart from the variables considered in the EC_RPL, there are also other sources of unobserved heterogeneity not taken into account in the model that explain farmers preferences toward AES. The negative sign of the coefficient means that olive growers are generally more willing to participate than not (that is, there is a negative willingness to choose SQ-option). During the interviews, two main reasons were found to explain this positive attitude toward participating in AES. Firstly, there were a certain number of farmers that already comply with most of the requisites of the AES-alternatives, or where the changes required within such alternatives were not perceived to be too drastic by farmers, thus leading them to choose AES instead of the SQ-option. In this regard, Hodge and Reader (2010) also reported that the initial condition of the farm/farmer was a strong determinant of AES uptake. Secondly, some farmers seem to adopt a "rent seeking" behavior, so they preferred AES-alternatives because of the related payment (which is also found in other EU regions, see Ingram et al., 2013). In the particular case of IOG, another potential explanation for the latter behavior is the fears of farmers regarding future CAP payment reductions for olive growing, but this is a matter that can be dealt with in future research.

The two interactions with the ASC_{SQ} provide further information about the initial attitude of IOG farmers when deciding whether to participate in AES or not. The interaction ASC_{SQ}×Oliarea20 is significant and positive, which means that those farms with less than 20 ha of olive groves (Oliarea20=1) are more willing to choose SQ and are generally less willing to participate in AES. These were in line with the findings of Falconer (2000), Ruto and Garrod (2009), Hodge and Reader (2010), among others. As these authors highlight, higher economies of scale and comparatively lower transaction costs are the main reasons for the greater willingness of farmers with large farms to participate in AES. The interaction ASC_{SQ}×SinglePaym750, which is significant and positive, indicates that farmers with average single payments of higher than €750/ha per year are less willing to participate in AES. In this respect, literature also identifies the competition of other CAP subsidies as a limiting factor to participate in AES (Uthes and Matzdorf, 2013).

4.3. AES scenarios: Supply-side approach

Table 4 shows the six different scenarios that have been set for the analysis. They represent different alternatives of AES, with different combinations of the attributes. There are three little restrictive scenarios, namely **EFA_2**, which only comprises EFA-2% requisite; **M_25**, comprising CCMA-Restr and CCAR-25% (representing past SM7); and **EFA_25**, which is an

AES with CCAR-25% and EFA-2%. There are two highly restrictive scenarios, **AES_Max** and **AES_MaxC**, which represent AES with all the attributes at its highest level (CCMA-Restr, CCAR-50% and EFA-2%) but with individual and collective participation respectively. Finally, there is also an intermediate scenario, **EFAM_25**, with CCMA-Restr, CCAR-25%, and EFA-2%. In all scenarios, MONI remained constant and equal to 5%, since it was not significant in the EC_RPL.

Table 4 about here

Table 5 shows estimates of farmers' compensating variations regarding each scenario. Compensating variations of IOG farmers range from €100.8/ha of the least stringent individual-AES scenario considered (i.e., EFA_2) to €349.1/ha of the most stringent one (AES_Max). Then, if collective participation is considered, €124.5/ha has to be added to each scenario (e.g., this is the difference between the compensating variation of AES_Max and AES_MaxC, being the latter €473.6/ha on average).

Table 5 about here

Figure 1 shows the rate of participation in AES both in terms of percentage of farmers and area for the different scenarios considered and for different payments. Clearly, the participation rate (in terms of both farmers and area) changes depending on the scenario considered. For example, at the €150/ha-level of payment 15% and 66% of the farmers would be willing to participate in AES_MaxC and EFA_2, respectively, which corresponds to the minimum and maximum rate obtained for the six scenarios. For any area-payment the participation rate is higher in terms of area than in number of farmers. For instance, the percentage of participating area ranges from 27% to 77% at the €150/ha-level of payment depending on the scenario. This difference between both ranges of percentage reflects the correlation found between farm area and AES uptake.

Figure 1 about here

With respect to farmers' participation, it should be noted that the more stringent the AES requisites, the less sensitive farmers are to payments. While the range of participation rate in the most stringent AES considered (AES_MaxC) for €0-400/ha of payment is 34% (from 4% to 38% for €0/ha and €400/ha, respectively), the rest of the scenarios considered range from 46% to 80%. Furthermore, Figure 1 shows the participation rate at €0/ha of payment, representing the percentage of farmers and area currently using the practices that are to be encouraged through AES (i.e., percentage of farmers/area that provides PGs at the level established in the AES without any incentive). Literature refers to the term “deadweight” when a policy measure is funding something (e.g., the use of an agricultural practice) that would have existed (been implemented) in the absence of such a measure. For example, for M_25 the deadweight would be 30% of farmers (representing 47% of the area), indicating that 30% of the farmers comply with the requisites included in this AES without receiving any payment for it. In contrast, deadweight is much lower for more stringent AES (e.g., for AES_Max it is 8% and 19% in terms of farmers and area, respectively).

Figure 2 shows budget estimates for the implementation of each scenario according to the level of payment, arrived at by multiplying the latter by the enrolled area at each payment. For example, if a payment of €150/ha were set for the implementation of AES M_25, 218,194 hectares of IOG would be enrolled, requiring a total budget of €50.7M. In this regard, it is worth pointing out that the less stringent scenarios would imply higher budgets, given that the participation rate would be higher. Logically, as it is easier for the farmers to comply with the requisites included in AES, the participation rate is higher and, as a result the associated budget is also higher.

Figure 2 about here

5. Demand-side approach and social welfare gains related to the implementation of AES

Policy-makers should seek net social welfare gains from the implementation of policy measures. The analysis explained in the earlier section focuses on the costs of implementing a policy measure that encourages PG production (IOG farmers’ WTA). In any case, it is also worth complementing this supply-side analysis with insights from the demand-side. Only by comparing both types of results would it be possible to estimate the net welfare gain (or loss) achieved when implementing each AES option. A demand-side analysis has therefore been carried out for the implementation of AES in IOG. It is worth commenting that the demand-side analysis carried out here only represents an exploratory exercise aimed at identifying the best AES options, but it is acknowledged that further empirical analysis is recommended in order to obtain more accurate estimates.

5.1. Secondary sources for demand-side assessment

An empirical analysis from the demand side is beyond the scope of this particular study. Secondary sources of information have therefore been used to explore the social values that could be obtained from improvements in PG production by IOG.

The work of Rodríguez-Entrena et al. (2012) is the main secondary source of information for carrying out this demand-side analysis. These authors used the CE approach to estimate welfare changes of the Andalusian society associated with improvements in the provision of three PGs by olive growing as a result of the adoption of certain environmentally-friendly practices (mainly, CC and shredded pruning debris): *carbon sequestration*, *soil conservation* and *farmland biodiversity*. They used indicators to measure changes in the production of the three PGs: tCO_2 sequestrated per hectare and year for carbon sequestration, t of soil loss prevented per hectare annually for soil conservation and the number of bird species per hectare for biodiversity. They calculated the following welfare changes with regard to these per-hectare indicators: €29.7/tCO_2 sequestrated; €4.2/t of soil loss prevented; and €0.6/bird-specie[3]. These are the main estimates used to elicit social welfare gains for each AES scenario considered here. Therefore, it is needed to estimate the production levels of these three PGs associated with each attribute level considered for the supply-side analysis and, afterward, estimate the production of these PGs for each of the AES scenarios. To do this, expert advice and additional studies, in addition to Rodríguez-Entrena et al. (2012), have been used to estimate the levels of production of the different PGs using the same indicators.

Table 6 shows attribute levels for the different PGs considered. With regard to *carbon sequestration*, the estimates provided by González-Sánchez et al. (2012) were used. These authors carried out a literature review about carbon sequestration related to the use of CC in Spain, obtaining an average sequestration of 1.78 tCO_2/ha per year. This figure has been set for the CCAR-25% level, while the 3.56 tCO_2/ha·year has been set for CCAR-50%. With regard to CCMA-Restr, it was set 0.18 tCO_2/ha·year according to Rodríguez-Entrena et al. (2012).

Table 6 about here

[3] These estimates are calculated using the results of Rodríguez-Entrena et al. (2012). In particular, these authors estimated willingness-to-pay per individual and year for improvements in carbon sequestration (€7.74 for a sequestration of 1.8Mt CO_2-eq), erosion control (€7.21 for 11.7Mt of soil loss prevented), and biodiversity (€2.90 for 5 bird-species/ha). The estimates highlighted in the main text are the result of multiplying these figures by the number of taxpayers in Andalusia and referring the resulting calculations to units of each PG (i.e., tons or birds).

With regard to *soil conservation*, results of Gómez et al. (2009) were used to set soil loss prevention related to the use of CC. From their results, the soil loss prevented using CC (at 33% of CCAR) was 4.1 t soil/ha per year compared to the non-use of CC. Thus, soil loss prevention using CCAR-25% and CCAR-50% were estimated in proportion to these results. The estimates by Rodríguez-Entrena et al. (2012) were used to set soil loss prevention for CCMA-Restr.

For *farmland biodiversity*, Rodríguez-Entrena et al. (2012) set the increase of biodiversity for CC compared to no CC at 7 bird-species/ha. This is the level set for CCAR-25%. The level of this indicator for CCAR-50% was set to 9.1 bird-species/ha after consulting experts in this field. For CCMA-Restr, the level of 7 bird-species/ha proposed by Rodríguez-Entrena et al. (2012) was used.

As mentioned at the start of the paper, it is worth mentioning that the proposed AES focuses on the four PGs with the highest potential for production enhancement. This means that the PG regarding the *visual quality of agricultural landscapes* also needs to be included in the demand-side analysis. For this purpose, firstly, it is assumed that the attribute CCMA-Restr does not provide a higher visual quality of landscape compared to CCMA-Free, since the visual effect of both treatments is similar. For the attributes CCAR and EFA, it is assumed that social welfare associated with this PG is proportionate to the social welfare associated with each of the other three PGs already analyzed, using the estimates provided by Gómez-Limón and Arriaza (2011) on Andalusian society's preferences toward the different functions provided by olive growing. Thus, the amount of this PG provided for each attribute level has been estimated as a percentage of the aggregated social welfare accounted for the other three PGs (i.e., not including *visual quality of landscapes*). The resulting figures are shown in Table 6.

Finally, it is also worth pointing out that, unfortunately, there are no available data regarding the impact of EFA on the production of the four PGs considered. Consequently, specialized literature and experts were consulted to set levels for the use of EFA. In particular, the following equivalences between EFA-2% and CC were used: 6% of CCAR managed at CCMA-Restr level for *carbon sequestration* and *soil conservation*; and 12% of CCAR managed at CCMA-Restr level for *farmland biodiversity*. The resulting amounts of CO_2 sequestrated and soil loss prevented per hectare annually are shown in Table 6. In the case of the visual quality of landscapes, the same procedure described in the previous paragraph is used. As a result, social welfare provided by EFA-2% regarding *visual quality of landscapes* is equivalent to 14% of the aggregate welfare provided by the other three PGs.

Table 7 shows estimates of gross social welfare gains for the attribute levels shown in Table 6. For the calculation of these estimates, it should be clarified that they reflect the social welfare changes associated from the reference levels (assuming CCAR and EFA to be zero, and CCMA to be CCMA-Free) and the levels established for each AES scenario. For example, a change from zero CCAR to CCAR-25% and CCAR-50% would result in gross social welfare gains for the Andalusian society of €78.8/ha and €153.8/ha, respectively. In this regard, it is also worth noting that linear effects in the continuous attributes have been assumed.

Table 7 about here

From this section, one thing is evident: the difficulty of matching results from both supply-side and demand-side analyses. Since both analyses were not initially considered to match each other, several assumptions and a notable review of literature have been required to match them, especially regarding the production of PGs (i.e., indicator levels) in the case study. It is therefore worth highlighting that there is an intrinsic obstacle in coordinating both supply-side and demand-side analyses of PGs provided by agricultural systems. While supply-side analyses are in terms of agricultural practices used by farmers, demand-side analyses are in terms of equivalents comprehensible to society (to derive society's preferences and values). For example, CO_2 emissions for different practices included in AES can be translated in terms of width of the CC strip or in terms of equivalent of emissions of a town of 1,000 inhabitants to help the farmers and the citizens, respectively, understand the level of PG provision requested.

5.2. AES scenarios: Demand-side approach

Using the estimates shown in Table 7 and the mean SQ situation of IOG-farmers, Table 8 has been created, which shows estimates of gross social welfare gains of Andalusian society obtained from changing from such SQ to the new situation of each AES scenario. As can be observed in this table, the gross social welfare gains obtained from the implementation of the AES considered range from €17.2/ha for EFA_2 to €150.0/ha for AES_Max. In all cases, these amounts are below average farmers' welfare changes estimated for participating in the different AES scenarios (see Table 5).

Table 8 about here

For the supply-side analysis, curves of aggregated gross social welfare gains in function of payments have been created (see Figure 3). These curves are calculated by multiplying the area registered for each payment and the per-hectare social welfare gains. By observing these curves, it is clear that the most stringent AES provide higher gross welfare gains than the least stringent ones. For example, for a payment of €150/ha, the maximum and minimum aggregated gross social welfare gains are obtained for AES_Max (€22.1M) and EFA_2 (€5.5M), respectively.

Figure 3 about here

5.3. Looking for the optimum AES scenario

After having shown results from both supply and demand side analyses, the next step is to carry out a comparison between them in order to determine which AES scenario would result in the highest net social welfare gains, and therefore the optimum choice for policy-making. For this purpose,

Figure 4 shows the cases of EFA_2 and AES_MaxC as examples. By observing both cases, it is obvious that EFA_2 is an inefficient policy option, since gross social welfare gains are lower than the budget estimates for all payment levels, in other words, the implementation of EFA_2 would lead to a net social welfare loss. In contrast, AES_MaxC could yield a net social welfare gain for payments lower than €130/ha, since for the range €0-130/ha, the gross social welfare gain curve is above the budget curve for some payment levels (the lower ones), the maximum difference (gain) being for a payment of €25/ha.

Figure 4 about here

For these estimates, it is worth pointing out that two main assumptions have been considered. Firstly, zero transaction costs are assumed (private and public)[4]. Secondly, for every payment level, it is assumed that payments are equal to farmers' rent forgone, in other words, the payment is simply the compensation required to maintain agricultural incomes (no income transfers are produced). With these two assumptions, a new figure of net social welfare gains (Figure 5) is arrived at and it is the difference of aggregated gross social welfare

[4] One could argue that to a certain extent, private transaction costs are included in farmers' WTA. The reasoning is that the farmer, when declaring his preferences, is implicitly considering transaction costs associated with each option. However, this is far-fetched because not all the farmers (very few, in fact) consider such costs when declaring their preferences toward policy measures. In any case, due to the lack of information about these private and public transaction costs, zero transaction costs are assumed for the purposes of this study.

gains and budget estimated for each AES and for each payment. Graphically, these curves are the difference between the corresponding curves shown in Figure 3 and Figure 2.

Figure 5 about here

From Figure 5, it is clear that society would not be interested in implementing three of the six AES scenarios considered (M_25, EFA_2 and EFA_25) as none of them provide positive net social welfare gains whatever the level of payment. These three AES scenarios are precisely the least stringent AES. For the three most stringent AES scenarios, only two of them (AES_Max and AES_MaxC) clearly present positive net social welfare gains, whereas EFAM_25 present little positive net social welfare gains (less than €1.0M) for a short interval of payments (€0-30/ha). Policy makers should therefore opt for one of the two most stringent AES.

Comparing AES_Max and AES_MaxC, the curve of net social welfare gain of the latter is fully above that of the former (see Figure 5). In particular, the latter presents net social welfare gains up to €130/ha, while the former does so up to €75/ha. Their maximum net social welfare gain are €8.2M and €6.6M, respectively, at €25/ha-payment in both cases (19% and 25% of participation rate in terms of area). So, a priori, society would be better off if AES_MaxC was implemented at €25/ha-payment.

6. Policy implications

Policy-makers face a great challenge when designing AES for IOG, given the large heterogeneity of the preferences of farmers. This study helps to support AES design by providing valuable information about AES uptake, both for an overall point of view and particularly for each attribute. From the policy-making perspective, this section highlights some of the relevant points that arise from the results obtained. It begins with some details on each attribute separately, and then goes on to provide an overall insight of the AES uptake and concludes by exploring the gains obtained from the implementation of AES, identifying the best AES options and outlining some relevant remarks with regard to the EU's agri-environmental policy.

6.1. Agronomic and design attributes

For CCAR, CCMA and EFA, trade-offs between private and PGs provision become apparent, at least through the farmers' eyes. The main challenge for the policy-maker is to overcome such trade-offs, and this requires a thorough understanding of how both kinds of goods are produced. For instance, in the case of **CCAR**, two different production relationships arise. For low CCAR (e.g., CCAR lower than 25%), there appears to be no trade-off, but a complementary relationship between private and PGs production. In this regard, the study shows that three-quarters of farmers use CC with an average CCAR of 21%, since they consider CC useful, primarily for preventing soil erosion and by extension, the long-term sustainability of the farms. These figures reflect the outcome of efforts made (through training and awareness campaigns, mainly) by Regional Government and professional associations to encourage the use of CC. These efforts should now focus on the remaining one-quarter of farmers that does not use CC. However, for a higher CCAR (e.g., CCAR higher than 25%) the trade-off becomes evident, since farmers consider that it represents a handicap for ground olive harvesting (i.e., the higher the share of ground olives harvested, the higher the WTA for CCAR increases). In this case, it is important to understand why farmers harvest ground olives and if an alternative solution could be found. The harvest of ground olives is a widely used practice due to its relative low cost (at least for traditional olive groves), although olive oil obtained from these olives is of a low quality due to their inferior organoleptic properties. As a result, the olive oil industry usually pays less for ground-harvested olives. Therefore, the alternative solution to overcome such a trade-off might be a market incentive to encourage the olive oil industry to establish a quality premium for early harvesting directly from the tree; for instance, implementing public promotion campaigns favoring the consumption of "virgin olive oil" (obtained from olives directly harvested from the tree) instead of simply "olive oil" (obtained from olives harvested from the tree or the ground), or promoting R&D activities focused on cheaper technologies for olives harvesting from the trees. Thus, by identifying the type and causes of the joint production, policy-maker can easily identify efficient ways to encourage PG provision, overcoming trade-offs with private goods provision.

With regard to CCMA and EFA, competitive relationships are likely to characterize the joint production of private and PGs. In the case of the CCMA, the relatively high estimated WTA points to farmers' low willingness to manage CC without tilling and/or with restrictions on the number of herbicide treatments. Two main reasons behind these results are resistant weed species and the farmers' beliefs regarding soil water conservation. It can be pointed that many olive growers are worried about the presence of resistant weed species within CC, and thus they have a negative perception of the reduction of permitted options for managing CC. Moreover, many producers consider tillage a useful way to reduce soil water evaporation during summertime. As a result, CCMA-Restr appears very stringent to most of the olive growers, so they ask for a moderate-to-high compensation to comply with such a requisite. Consequently, the large budget required for the implementation of CCMA-Restr to IOG means that policy-makers should only consider this practice in certain circumstances (e.g., in environmentally-sensitive areas).

When considering **EFA**, there is also a moderately high WTA. Yet, observing welfare estimates of the EFA_2 scenario (€100.8/ha of compensating variation on average), it seems that 30% of the single payment assigned in the new CAP regulation to green payments (equivalent to €229.8/ha on average for the farms surveyed) would be enough to encourage a green payment if EFA_2 was considered as a requirement in IOG. Actually, with a payment of €229.8/ha, 85% and 95% of participation rate would be obtained in terms of farmers and area, respectively. So, in this scenario it seems that a vast majority of IOG farmers would be strongly rewarded for a modest additional commitment to the environment. Nevertheless, for higher shares of EFA (e.g., 5-7%), it is unlikely that such a level of payments would be enough for farmers to apply for green payment. Indeed, assuming linear WTA for the interval of 0 to 7% of EFA, estimates of compensating variation for the scenarios EFA_5 and EFA_7 (equivalent to EFA set for arable crops in the CAP regulation, i.e., 5% although this will probably be increased to 7% in 2017) would be €300 and €427.4/ha, respectively, well above the likely green payment in IOG (i.e., €229.8/ha, mentioned earlier). Yet, linear WTA is a strong assumption with regard to EFA, given that IOG farmers' WTA would probably rise as the share of EFA increases, since the space for these areas is very limited in IOG. Therefore, the main policy implication that arises from the results is that although there is room for devoting some part of IOG land to EFA (e.g., 0-3%), it would be very difficult for farmers to comply with higher shares of EFA. Also, in the design of new green payments in IOG, if EFA were set at 2-3%, it would be worth including this requirement as a further environmental requisite.

With regard to **COLLE**, there are several policy implications that can be outlined from the results. Firstly, the EU-wide up-to-30% bonus set in the regulation of the CAP 2014-2020 does not appear to be enough to promote collective participation in IOG. In any of the scenarios considered, adding a 30% to compensating variations would not overcome the €124.5/ha needed for collective participation. However, our results indicate that olive growers' WTA for collective participation is sensitive to the stringency of sanction system specifically designed for this participation and to farmers' opinion about their farm takeover. With regard to the former, IOG farmers refused collective participation particularly when monetary sanctions due to other farmers defaulting were imposed. While this calls for a careful design of the sanction system in collective AES, further research is needed to support such a design. In particular, this new research should be aimed at finding a sanction system that encourages group self-control of moral hazard but does not totally discourage farmers' participation in collective AES. With regard to the latter, when the farmer thinks there will not be a farm takeover, the 30% bonus is more likely to be enough to encourage the farmer's collective participation in AES. Actually, there is one scenario where these farmers would participate collectively using the 30% bonus, which is AES_Max (with €349.1/ha of compensating variation; the subsequent 30%-bonus of €104.7/ha overcomes €72.4/ha WTA collective participation by farmers that think there will be no farm takeover). To overcome this issue, one possible option could be that, when a known successor is expected to take over farm management, not only the predecessor but also the successor should be involved in the process of signing collective contracts (e.g., informing both of them, including a specific clause in the collective contract regarding the case of farm takeover, etc.). Finally, two more policy recommendations for promoting collective participation in AES can be outlined from the results, which are the use of facilitators (e.g., olive oil cooperatives in IOG) for signing AES contracts and informing farmers about the environmental benefits of this type of participation.

There are some issues of collective participation that require further research. With regard to the collective bonus, it is clear that it has to be large enough to promote collective participation but at the same time not larger than the gains it generates. Still further research is needed to estimate such gains and get the necessary information to set the right bonus. In this regard, it is worth commenting that expected gains from the reduction of transaction costs could easily be estimated. However, those deriving from the higher environmental performance are far more difficult to quantify as they depend not only on the requisites/practices included in the AES, but also the proximity and configuration of enrolled farmland (Sutherland et al., 2012). These facts evidence that an up-to-30% bonus can be considered too rough an estimation to reflect society's net gains from collective participation. Moreover, it would be interesting to further analyze other forms of incentives, like non-monetary ones (e.g., giving priority to collective rather than individual applications to AES), or directly not offering individual AES but only collective contracts. Clearly, further research is needed to cover knowledge gaps about costs and –in particular– gains of collective participation, the types of incentives and the sanction system to be implemented.

6.2. AES scenarios

The main policy implication obtained from the double analysis of supply-side and demand-side is that only the implementation of the most stringent AES scenarios provides positive net social welfare gains and should therefore be considered by policy-makers. On the contrary, if policy maker decided to implement the least stringent AES, this would produce disutility to the Andalusian society as a whole as farmers would be paid for no or very small increases in the production of PGs.

Moreover, it is worth underlining that results obtained show little net gains from implementing AES in IOG. In particular, positive net social welfare gains are only achieved using low levels of payments and low participation rates. In addition, if transaction costs and income transfers were included in the calculation of net social welfare gains (that is, if the assumptions of zero transaction costs and no income transfers were relaxed), hardly any AES scenario would yield positive net social welfare gains. This is not surprising since IOG is characterized by semi-intensive farming, that is, this agricultural system is very oriented to the production of private goods. As a result, IOG-farmers face high opportunity costs when asked to increase their production of PGs; consequently, high payments are usually required to outweigh these costs and incentivize AES uptake. Yet, large farms can overcome this barrier to participation since they usually make use of economies of scale, hence they can adopt practices at a lower cost. Accordingly, large farms are usually more willing to participate in AES, which is something that has been reported for IOG in the results discussed above. This is also reflected in the positive slopes found at the beginning of the curves of net social welfare gains of the only two viable scenarios (AES_Max and AES_MaxC), the reasoning being that large farms are usually willing to participate in AES at payments low enough to result in positive net social welfare gains. However, when payments increase, it is these same large farms that benefit the most, as they are willing to participate at low levels of payment. In these cases, most of the payment can be considered income transfer, though this is an old issue in agri-environmental policy.

Finally, it is worth reminding the exploratory nature of the demand-side analysis carried out here. Actually, it is likely that, if transaction costs and income transfers are included in the calculation of net social welfare gains, no AES scenarios would yield positive net social welfare gains in IOG. Therefore, the implementation of these AES in such an agricultural system may be questionable as, presumably, there would be other agricultural systems which would present higher net gains from AES.

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Tables

Table 1. Attributes and levels used in the choice set design.

Attribute [Acronym]	*Explanation*	*Levels*
Cover crops area [CCAR]	Percentage of the olive grove area covered by cover crops	- 25% - 50%
Cover crops management [CCMA]	Farmer's management of the cover crops	- Free - Restrictive management
Ecological focus areas [EFA]	Percentage of the olive grove plots covered by ecological focus areas	- 0% - 2%
Collective participation [COLLE]	Participation of a group of farmers (at least 5) with farms located in the same municipality	- Individual participation - Collective participation
Monitoring [MONI]	Percentage of farms monitored each year	- 5% - 20%
Payment [PAYM]	Yearly payment per ha for a 5-year AES contract	- €100/ha per year - €200/ha per year - €300/ha per year - €400/ha per year

Source: Own elaboration.

Table 2. Error Component Random Parameter Logit Model.

Parameter	*Mean values*		*Standard deviations*	
	Coef.	*St. Error*	*Coef.*	*St. Error*
CCAR	-0.038*	0.017	0.097***	0.016
CCAR×Groundharv	-0.002***	0.000		
CCMA	-2.303***	0.531	1.956***	0.397
CCMA×Educa2	1.403*	0.682		
EFA	-0.621**	0.226	0.867***	0.156
EFA×No-training	-0.695*	0.279		
COLLE	-2.168***	0.413	1.706***	0.350
COLLE×No-takeover	1.187*	0.584		
MONI	-0.009	0.012		
PAYM	0.014***	0.001		
ASC_{SQ}	-3.563***	0.917		
$\varsigma_{No\ SQ}$			3.519***	0.581
Covariates				
ASC_{SQ}×Oliarea20	2.453**	0.910		
ASC_{SQ}×SinglePaym750	2.163*	0.946		
LL=-887.7				
McFadden Pseudo-R^2 = 0.441				
Valid respondents/choices: 102/816				

*, **, and *** reflect significance level of 5%, 1%, and 0.1% respectively.
Source: Own elaboration.

Table 3. Mean WTA of the attributes (€/ha per year)[1], and extreme farmer's profiles of WTAs.

Attribute	*Mean*[2]	*St. Error*	*Farmers profile*[3]	
			Most willing	*Least willing*
CCAR	6.2***	1.0	2.8	17.2
CCMA	115.2***	25.3	66.5	170.1
EFA	64.6***	12.4	45.9	97.1
COLLE	124.5***	25.0	72.4	160.1
MONI	0.7	0.9	0.7	0.7

[1] In the case of EFA, MONI and CCAR, it is € per 1% of EFA in olive groves area, 1% of farms monitored, and 1% of cover crops in olive groves area, respectively.

[2] Estimates are calculated using the mean values of the variables included as interactions with the attributes.

[3] Farmers-most-willing to participate in AES: 0% of olives harvested from the ground; have at least a secondary school education; have undergone some professional training; think there will be no farm takeover. Farmers-least-willing profile is the opposite (i.e., 100% of olives harvested from the ground, do not have at least a secondary school education, etc.).

*, **, and *** reflect significance level of 5%, 1%, and 0.1% respectively.

Source: Own elaboration.

Table 4. AES scenarios considered for the analysis.

Scenario	***COLLE*** *(1=collective participation)*	***CCMA*** *(1=CCMA-Restr)*	***EFA*** *(% of olive tree area)*	***MONI*** *(% of monitored farms)*	***CCAR*** *(% of olive tree area)*
EFA_2	0	0	2	5	0
M_25	0	1	0	5	25
EFA_25	0	0	2	5	25
EFAM_25	0	1	2	5	25
AES_Max	0	1	2	5	50
AES_MaxC	1	1	2	5	50

Source: Own elaboration.

Table 5. Mean farmers' compensating variation for different AES scenarios, in €/ha.

Scenario	*Mean*	*St. Error*
EFA_2	100.8***	19.3
M_25	160.4***	21.7
EFA_25	129.5***	16.6
EFAM_25	230.3***	23.2
AES_Max	349.1***	33.8
AES_MaxC	473.6***	47.4

*** reflects significance level of 0.1%.

Source: Own elaboration.

Table 6. Attribute levels for the different PGs considered (per ha).[1]

Attribute levels	*Carbon sequestration (tCO_2-fixated)*	*Soil conservation (t of soil loss prevented)*	*Farmland biodiversity (bird-species)*	*Visual quality of landscapes (%)*
CCAR-25%	1.78	3.11	7.00	12%
CCAR-50%	3.56	6.21	9.10	12%
CCMA-Restr	0.18	2.00	7.00	0%
EFA-2%	0.47	1.23	6.72	14%

[1] These figures have the implicit reference of CCAR-0% with conventional tillage for CCAR-25% and CCAR-50%, CCMA-Free for CCMA-Restr and EFA-0% for EFA-2%.

Source: Own elaboration based on Gómez et al. (2009), Gómez-Limón and Arriaza (2011), González-Sánchez et al. (2012), Rodríguez-Entrena et al. (2012), and expert advice.

Table 7. Gross social welfare gains of the Andalusian society for attribute levels (€/ha).[1]

Attribute level	*Carbon sequestration*	*Soil conservation*	*Farmland biodiversity*	*Visual quality of landscapes*	*Total*
CCAR-25%	53.2	13.0	4.1	8.5	78.8
CCAR-50%	106.5	26.0	5.3	16.0	153.8
CCMA-Restr	5.4	8.4	4.1	0.0	17.8
EFA-2%	14.1	5.1	3.9	3.3	26.4

[1] Obtained by multiplying the figures provided in Table 6 by the estimates of Rodríguez-Entrena et al. (2012), which are: €29.7/t CO_2 fixated; €4.2/t of soil loss prevented; and €0.6/bird-species/ha. In the case of visual quality of landscapes, percentages shown in Table 6 were multiplied by the sum of welfare changes associated with the other three PGs.

Source: Own elaboration based on Rodríguez-Entrena et al. (2012).

Table 8. Mean gross social welfare gains of the Andalusian society for AES scenarios (€/ha).[1]

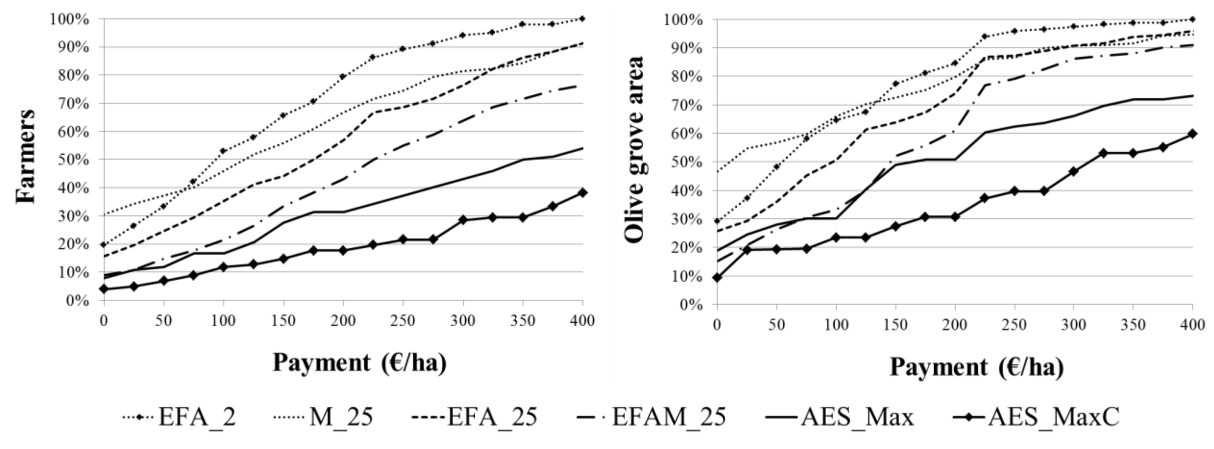
Scenario	*Carbon sequestration*	*Soil conservation*	*Farmland biodiversity*	*Visual quality of landscapes*	*Total*
EFA_2	9.1	3.3	2.5	2.2	17.2
M_25	10.5	6.9	3.0	1.2	21.5
EFA_25	16.4	5.1	3.1	3.3	27.9
EFAM_25	19.6	10.2	5.6	3.3	38.7
AES_Max	72.9	23.2	8.0	11.3	115.4
AES_MaxC					150.0

[1] Estimates shown in Table 6 and Table 7 have been used. The reference level is represented by the mean SQ-situation, that is: 21.6% of CCAR, 39% of farmers that use CCMA-Restr, and 0.7% of EFA. In the case of AES_MaxC, bonus of 30% set by R (UE) 1305/2013 Art. 28.6 was used as a proxy of higher gains from collective participation.

Source: Own elaboration.

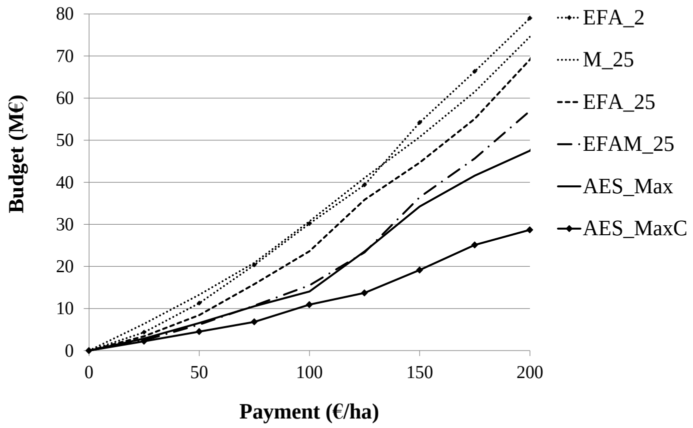
Figures

Figure 1. Participation in different scenarios of AES and payments.



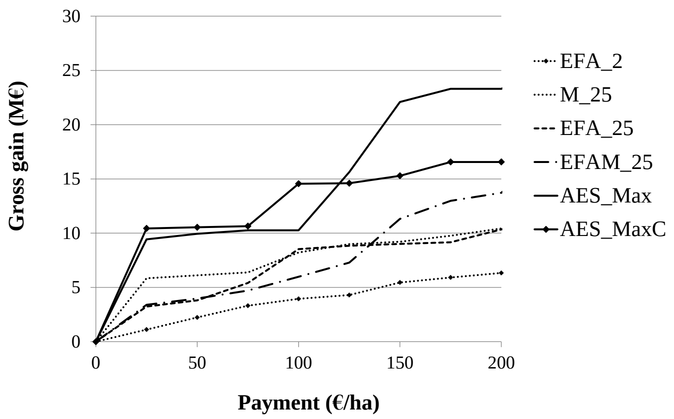
Source: Own elaboration.

Figure 2. Budget estimates for each scenario of AES and different payments.



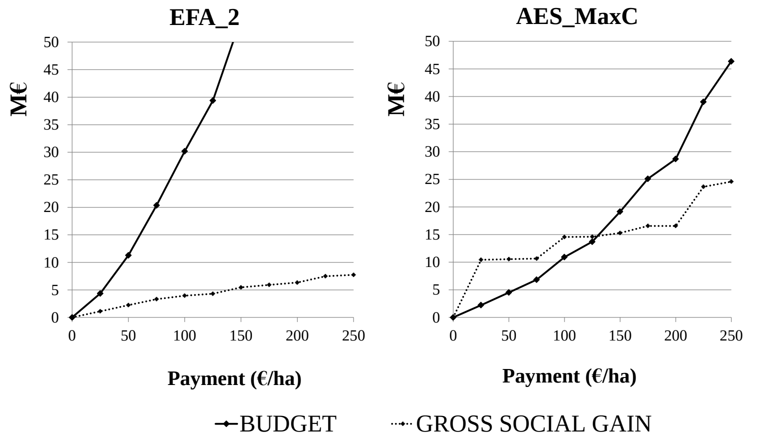
Source: Own elaboration.

Figure 3. Aggregated gross social welfare gains for each scenario of AES and level of payment.



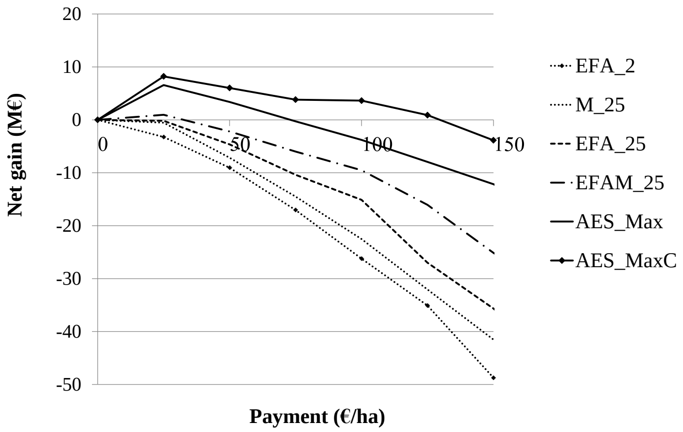
Source: Own elaboration.

Figure 4. Budget and gross social welfare gains for EFA_2 and AES_MaxC and different payments.



Source: Own elaboration.

Figure 5. Net social welfare gains for each scenario of AES and different payments.



Source: Own elaboration.