Demand for non-commodity outputs from mountain olive groves[1]

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Abstract

Agricultural multifunctionality is the recognition of the joint exercise of economic, environmental and social functions by this sector. In order to make this concept operative to support the design of public policies, it is necessary to estimate the social demand for such functions. The main objective of this article is to present an empirical application in this line. For this purpose we have adopted the agricultural system of mountain olive groves in Andalusia (Southern Spain) at risk of abandonment after the decoupling of the EU subsidies as a case study. The economic valuation technique used is the Choice Experiments. According to the results, each attribute included in the concept of multifunctionality makes a different contribution to the improvement of the utility at societal level. Thus, and taking into account its willingness to pay (WTP) for each attribute, maintaining rural population levels in villages and fighting soil erosion seem to be the functions most valued by citizens of Andalusia. These functions are followed by improvement in the visual quality of the rural landscapes and the reduction of phytosanitary residues in food. Finally, although the results suggest that there is a significant demand for the various functions, this demand is heterogeneous, and depends on the socio-economic characteristics of the individuals.

Key-words: *Agricultural multifunctionality; Economic valuation; Choice experiments, Olive groves, Andalusia (Spain)*

Introduction and objectives

In recent years, many researchers have paid attention to this new whole idea of agricultural multifunctionality. However, most studies have focused on the theoretical basis underpinning this concept and on its qualitative analysis (for example, Anderson 2000; Cahill 2001; Vatn 2002; Peterson *et al*. 2002; Van Huylenbroeck and Durand 2003; Prety 2003; Batie 2003; Brouwer 2004). Among these, it is worth mentioning the initial contribution to the debate of the OECD (2000). Subsequently, an International Seminar

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gathered all major studies in 17 countries (OECD 2001), pointing out the relative scarcity of empirical works that limited the potential for public intervention to act in accordance with this new paradigm (OECD 2003). However, more recently a growing number of studies have put some effort into making quantitative analyses of multifunctionality, as was demonstrated in the seminar organized by the European Association of Agricultural Economists in Rennes (*Multifunctional agriculture, policies and markets: Understanding the critical linkage*) in 2004 and in other published studies (e.g. Bennett *et al*. 2004; Yrjölä and Kola 2004; Colombo *et al*. 2005).

In considering the empirical analysis of multifunctionality we find two clear approaches: (a) that of focusing on the *supply side* of the agricultural systems (provision of commodities and non-commodities outputs) and (b) that which focuses on the *demand side*, taking into consideration social welfare changes due to variation in the supply of different outputs. The combination of both approaches is necessary in order to determine the optimal provision of goods and services from the agricultural sector from a social point of view. In theory, once the optimum has been located, the agricultural policy authorities will be in a position to design appropriate policy instruments to correct market failures existing in real world.

As a revision by OECD (2001) shows, the vast majority of empirical studies have taken the first approach, i.e. they analyse specific related issues in terms of the joint production of agricultural outputs (commodities and non-commodities), market failures or options for ensuring the provision of non-commodity outputs from multifunctional agriculture. However, the present study aims to expand the relatively sparse literature on the demand side of multifunctionality (Lima e Santos 2001; Randall 2002; Hall *et al*. 2004).

The choice of the mountain olive groves of Andalusia (Southern Spain) as a case study is justified by the recent decoupling of UE olive oil subsidies after the Mid-term Review of the CAP (Rule CE 864/2004). As a consequence of this policy reform, olive grove owners are entitled to receive up to 95% of the subsidies in the base period (from 1999/00 to 2002/03) as area payment with no need to harvest their olives. Therefore, a large number of olive growers, mostly located in mountain area whose yields are lower and costs of production higher, will probably opt for the abandonment of these groves. As Beaufoy and Pienkowski (2000) point out, abandonment of these mountain areas has implications of economic (lower local production of olive oil), social (depopulation of rural areas), environmental (soil erosion) and cultural (change of traditional landscape) importance.

Since the production function of these agricultural systems is at stake, it would appear to be relevant to assess the importance that society attaches to the non-market goods provided by olive plantations in mountain areas. We therefore carried out a survey of Andalusian citizens using the Choice Experiments procedure to address the importance of these plantations and the willingness of the sample to pay for the following non-commercial functions: provision of landscape, soil erosion control, food safety and maintenance of rural population in rural areas.

The remainder of this paper consists of five main parts. Section 2 explains the methodology followed in this research. The next two sections introduce the area studied and the empirical application of the Choice Experiments technique implemented. In Section 5 the models are estimated and the results are discussed. Finally, some conclusions are outlined.

Methodology

Approach to multifunctionality valuation

As Randall (2002) points out, the management of the multifunctional concept should involve the *joint valuation* of all the externalities generated in the production of agricultural commodities. By doing so, we avoid the adding-up problem (the sum of the parts usually exceeds the total), as Hoehn and Randall (1989), and Hoehn and Loomis (1993) demonstrate.

In order to carry out the analysis, not only does the valuation approach has to be determined, but also its scope. In this research we selected the *agricultural system* as our unit of analysis on the basis of three aspects: (a) the homogeneity of the externalities generated in the process; (b) the prospect of contributing to the design of policy instruments with local and geographically wider implications; and (c) the possibility of making case study comparisons with other cases.

Valuation technique: the Choice Experiments

Hall *et al*. (2004) describe the array of techniques available to valuations of the whole set of goods and services provided by the agriculture. They outline five possibilities: (a) opinion surveys; (b) the use of proxies to estimate public preferences; (c) consensus methods (focus groups, public juries, interviews, Delphi method); (d) monetary valuation; and (e) multicriteria techniques. Of these techniques, Hall *et al.* favour monetary valuation since, unlike the other alternatives; this technique relies on the same theoretical axioms as those that underpin consumers' decision processes. Within the range of monetary valuation techniques some alternatives are available for assessing the multifunctionality of agricultural systems, namely, the Contingent Valuation and the Choice Experiments (hereafter, CE). In this study we opted for the latter due to its suitability for evaluating "complex goods", i.e., goods that comprise several parts or attributes, as is the case of agricultural multifunctionality (a set of externalities).

CE involves the characterization of the object of study, in our case agricultural multifunctionality, through a series of attributes, which can be combined to create hypothetical scenarios to be evaluated by the subject. Usually, the number of scenarios in each choice set shown to the interviewee is three, the first one being the *status quo* (current levels of the various attributes) with zero additional cost, and the other two representing changes in the levels of one or more attributes. The new levels imply an improvement over the *status quo* situation and involve an extra cost for the subject that, in most cases, is paid via his/her annual taxes. Furthers details of this methodology can be found in Hensher *et al*. (2005), Bennett and Blamey (2001) and Louviere *et al*. (2000).

Some empirical applications of this methodology to environmental and agricultural issues can be found in the seminal works of Adamowicz *et al*. (1994), which evaluated the public's recreational preferences for Canadian rivers, Boxall *et al*. (1996) and Adamowicz *et al*. (1997), for Canadian hunting areas and Bergland (1997) for agricultural landscapes in Norway. Afterwards, the number of studies using this stated preference method has rapidly increased to make it one of the most frequently employed analytical methods. Spanish works include the empirical studies of Mogas *et al*. (2005) on the valuation of Catalonian forest externalities, and of Colombo *et al*. (2005), who analysed the problem of soil erosion in Southern Spain.

Econometric modelling of CE

The conceptual foundations of CE rely on Lancaster's Theory of Value (Lancaster 1966), which proposes that utilities for goods can be decomposed into separable utilities for their characteristics or attributes, and the Random Utility Theory (Thurstone 1927), which explains the dominance judgments made between pairs of offerings. Within this theoretical framework, subjects choose among alternatives according to a utility function with two components: a systematic (i.e. observable) component plus a random term (non-observable by the researcher). Mathematically:

$$U_{in} = V_{in} (Z_i , S_n) + \varepsilon_{in} \qquad (1)$$

where U_{in} is the utility provided by alternative i to subject n, V_{in} is the systematic component of the utility, Z_i is the vector of attributes of alternative i, S_n is the vector of socio-economic characteristics of the respondent n, and ε_{in} is the random term.

Of the available probabilistic choice models, the *conditional logit* (CL) model (McFadden 1974; Ben-Akiva and Lerman 1985) is the most frequently employed model for dealing with CE-sampled data. In this model specification, the condition of independent and identically distributed (IID) errors according to a Gumbel (or Weibull) distribution must be met. Such a distribution in the error terms allows for the verification of the independence of irrelevant alternatives (IIA) property, known as Luce's axiom (Luce 1959), which implies that the ratio of the probabilities of choosing any pair of alternatives i and j $[P(i/C_n)/P(j/C_n)]$ is not dependent on the systematic utility of any other alternative within the set of alternatives C_n. To validate the IIA property, the most common test employed is that of Hausman and McFadden (1984).

According to the CL model, the probability that an individual n will choose alternative i (P_{in}) among other alternatives j (j= 1…J) of a set C_n is formulated as follows (McFadden 1974):

$$P_{in} = \frac{e^{\mu V_{in}}}{\sum_{j=1}^{J} e^{\mu V_{jn}}} \qquad \forall\, j \in C_n \qquad (2)$$

where V_{in} is the systematic component of the utility provided by alternative i, and μ is a scale parameter which is inversely proportional to the standard deviation of the error terms and usually is assumed to be equal to one (Ben-Akiva and Lerman 1985).

Equation 2 enables the probability of choice of an alternative to be linked to its utility. To determine the relative importance of the attributes within the alternatives, the functional form of V_{in} must be specified. The most common assumption of this function is that it is separable, additive and linear[1] (Equation 3):

$$V_{jn} = ASC_j + \sum_k \beta_k X_{kj} \qquad (3)$$

where:

ASC_j = specific constant of alternative j (Alternative Specific Constant[2])
j = 1…J, representing the selected alternative within the set of alternatives (C_n).
k = 1…K, representing the attributes which characterize alternative j.
β_k = model parameter of attribute k.
X_{kj} = value of attribute k in alternative j.

From Equations (2) and (3) we obtain the *basic CL model* (Equation 4):

$$P_{in} = \frac{e^{ASC_i + \sum_k \beta_k X_{ki}}}{\sum_{j=1}^{J} e^{ASC_j + \sum_k \beta_k X_{kj}}} \tag{4}$$

As most empirical studies show (e.g. Mazzanti 2003), the inclusion of socio-economic variables improves the explanatory capability of the model. These models include such a variables in the utility functions as interactions (Greene 2000), like in Equation 5:

$$V_{jn} = ASC_j + \sum_k \beta_k X_{kj} + \sum_p \alpha_p (ASC_j \times S_{pn}) \tag{5}$$

where:

p = 1…P, representing the socio-economic characteristics of individual n.

α_p = interaction coefficient between ASC and the socio-economic characteristic p.

$ASC_j \times S_{pn}$ = interaction term between ASC and the socio-economic characteristic S_{pn}.

Substituting Equation (5) into (2) we obtain the hybrid CL model used in this study to estimate the demand of non-commodity goods from olive groves revealed by different social groups (Hensher *et al*. 2005). Once the parameters of the hybrid CL model have been estimated, the Marginal Rate of Substitution (MRS) between attributes can be obtained. Since one of the attributes is monetary, it is possible to determine its "implicit price" (IP) or part-worth. Mathematically, for a basic CL model the value is obtained as follows:

$$IP_{non-market\_attribute} = -\left(\frac{\beta_{non-market\_attribute}}{\beta_{monetary\_attribute}}\right) \tag{6}$$

Case study

Mountain olive groves in Andalusia

Any definition of mountain olive groves requires us to consider both physical (primarily slope and soil type) and economic aspects. As far as the first category is concerned, Guzmán (2004) adduces two physical criteria; the average inclination (slope) of the plantation being greater than 15% and the poor agronomic quality of the soil. This classification enables us to estimate the surface area of mountain olive groves in Andalusia at around 220,000 hectares (ha), i.e. approximately 16% of the total area given over to olives in Andalusia.

From an economic perspective, mountain olive groves, which are also known as "low productivity" or "marginal" groves, are typified by poor crop yields and high production costs. The coming into effect of the latest revision of the Common Market Organisation (CMO) for olive oil, which involves the decoupling of 95% of the price subsidies received until now by oil producers, has placed such groves beneath the threshold of profitability. For this reason we can assume that a large share of such growers will discontinue their productive activity. Certain authors (Arriaza *et al*. 2002) have suggested that this process of abandonment may even exceed one third of the groves located in mountainous areas.

Multifunctionality of mountain olive groves in Andalusia

Like other extensive agricultural systems (low input, low output), mountain olive groves tend to be found in areas of high environmental and landscape value. From a socioeconomic point of view, they represent an important element in income generation in rural zones at risk of depopulation and with virtually no alternative sources of agricultural income (Consejería de Agricultura y Pesca 2003). Likewise, Viladomiu and Rosell (2004) emphasize the multifunctionality of mountain olive groves, suggesting other functions in addition to their primary function of producing oil:

- Generation of secondary activities: production of quality products, generally produced under the label of denominations of origin.
- Generation of tertiary activities: support for leisure activities and the maintenance of local production systems.
- Control and distribution of water in the headwaters of local hydrological resources (limitation of water runoff and erosion).
- Provision of traditional agricultural landscapes.

In line with this classification of non-commercial functions of mountain olive groves, the present study analyses the multifunctional character of this particular agricultural system in a quadruple perspective: a) provision of landscapes of high visual quality and the conservation of biodiversity, b) control of erosion, c) provision of safe healthy food, and d) maintenance of rural population levels.

Regarding the first of these aspects mentioned above, it is sufficient to note that the intrinsic characteristics of mountain olive groves give them a high visual quality due to their location in high-altitude zones and in many cases, the use of vegetable cover and the presence of other species of bushes and trees, particularly in the cases of organically farmed olive groves.

The problem of soil erosion is particularly serious where olive groves planted on slopes steeper than 10% are concerned, a category that includes all mountain olive groves. Some studies (Pastor *et al.* 1999) estimate that soil losses in such zones are currently greater than 80 tonnes/ha/year, which implies a loss of the upper layers of the soil (Cuesta 2005). This erosion has the direct negative effect of reducing agricultural production, to which we must add the progressive desertification of the territory, the sedimentation of reservoirs, the contamination of water resources, etc. (Colombo *et al.* 2005).

The supply of safe and healthy food is a requirement that has been progressively emphasized in the successive reforms of the CAP. In the case of the agricultural system being analysed here, as in other agrarian sectors, the healthiness of the food produced (olive oil in this case) is dependent on the presence of residues of phytosanitary products (Raymond *et al*. 2005), which depends in turn on the system of production in use.

Finally, perhaps we ought to mention that the evolution of the concept of sustainable development has accentuated the territorial nature of the economic development of high-altitude zones (Ortuño and Zamora 2001). In the case of mountain olive groves, it is sufficient to indicate that this system of production is associated with family farms, which in turn favour the retention of the rural population and encourage the diversification of rural economic activities, such as handicrafts and rural tourism.

Empirical application of CE

Bennett and Blamey (2001) have described the phases involved in the design and implementation of CE. In accordance with these authors and in connection with case study we have the following phases:

Determination of attributes and their levels

The choice of attributes should be based on two objectives: first, the information gathered must be relevant to policy-makers for the design of policy instruments; second, the scenarios presented to the public through these attributes must be realistic and easy to understand. In order to satisfy both of these conditions, the choice of attributes in this research in order to define agricultural multifunctionality was based on the results of a poll of 3,192 Andalusian households about the functions that agriculture plays in this society (IESA 2004). These results confirmed that the most important attributes conforming public opinion on this subject are the same ones pointed out before: a) Visual quality of landscapes and preservation of biodiversity, b) Prevention of soil erosion, c) Food safety and d) Keeping farmers in rural areas. Additionally, the monetary attribute (cost of the alternative) that the CE needed to be implemented had as well been included. Furthermore, appropriate proxy variables to measure these attributes were required. For this purpose we were helped by a focus-group discussions that also contributed in the determination of their levels, as Table 1 shows:

Supporting the outcome of the focus-group about the selection of the proxy variables we have:

- *Percentage of agricultural land covered by other fruit trees*. A number of studies claim that the variety of vegetation have a positive effect on both the visual quality of the landscape and biodiversity richness (Real *et al*. 2000; Franco *et al*. 2003; Arriaza *et al*. 2004; Palmer 2004).
- *Soil loss*. This variable proxy is easily understood by interviewers as well as commonly used as erosion indicator (Beaufoy and Pienkowski 2000; Merritt *et al*. 2005; Navas *et al*. 2005).
- *Level of residual substances*. The attribute of food safety posed some complications due to the public's perception of olive oil safety. Yet, the increasing importance of this attribute (Raymond *et al*. 2005) suggested its inclusion in the analysis.
- *Percentage of farm abandonment*. Rural depopulation and farm abandonment have been two parallel observable facts in many European rural areas (Schmitz *et al*. 2003; Conti and Fagarazzi 2004). This relationship is accentuated in mountain olive groves due to their high labor demand.

Table 1. Attributes, variables and levels used in the CE

Attributes	Proxy variables	Levels
Visual quality and preservation of biodiversity	Percentage of other fruit trees in the mountain areas (*LANDSCAPE*)	*Status quo*: Only olive groves (0% other fruit trees) Level 1: 10% of the area with other fruit trees Level 2: 20% of the area with other fruit trees
Prevention of soil erosion	Rate of soil erosion in t/ha/year (*EROSION*)	*Status quo*: 13 t/ha/year Level 1: 5 t/ha/year Level 2: 1 t/ha/year
Food safety	Amount of residuals in the food (*FOOD SAF.*)	*Status quo*: Current level Level 1: Half of the current level (50% reduction) Level 2: Minimum level of residuals (100% reduction)
Keeping farmers in rural areas	Percentage of abandoned farms after policy reform (*KEEP POP.*)	*Status quo*: 50% of farm abandonment Level 1: 25% of farm abandonment Level 2: 10% of farm abandonment
Additional cost of the alternative	Levy on income tax (*TAX*)	*Status quo*: 0 euros/hab/year Level 1: 10 euros/hab/year Level 2: 20 euros/hab/year Level 3: 40 euros/hab/year

Experimental design

Following an orthogonal fractional factorial design, in which only a chosen fraction of a full factorial experiment is selected, we estimate all main effects. This statistical design enables us to reduce the number of sets from the initial 3^5x3^5 in the full design to 27 choice sets[3]. Even so, this number was still too high to be presented to the subjects (Swait and Adamowicz 2001). Therefore, we decided to separate them into blocks: the 27 sets were randomly divided into three blocks of four sets and three blocks of five sets. Figure 1 shows one of these choice sets.

Sample selection

First, the target population of the study comprises citizens above the age of 18 living in the Autonomous Region of Andalusia (about 5.6 millions of inhabitants). In doing so, we focus our attention on the local demand (Andalusians) for this type of goods. The decision is based on the impossibility of determining *a priori* the geographical limits of the population that would be interested in the provision of such goods by this agricultural system. Furthermore, the bias due to the embedding effect (see Kahneman *et al.* 1991; Randall and Hoehn 1996) from selecting non-residents would be increased. Yet, although there is a positive willingness-to-pay for these goods among non-residents they were not included in the study. This limitation should be considered when analyzing the aggregate values obtained.

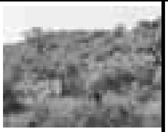
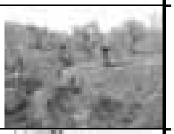
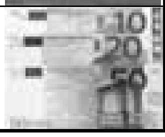
Block 1 ***CHOICE 3***		***No intervention***	***Option A***	***Option B***
Visual quality and preservation of biodiversity		**Exclusively olive groves (0% other fruit trees)**	**20% other fruit trees**	**Exclusively olive groves (0% other fruit trees)**
Prevention of soil erosion		**Soil loss: 13 ton/ha.year**	**Soil loss: 5 ton/ha.year**	**Soil loss: 1 ton/ha.year**
Food safety		**Residual level: Current (0% reduction)**	**Residual level: Half (50% reduction)**	**Residual level: None (100% reduction)**
Keeping farmers in rural areas		**Farm abandon-ment: 50%**	**Farm abandon-ment: 10%**	**Farm abandonment: 50%**
Additional cost of the alternative		**0 €**	**20 €**	**40 €**
Supposing these options are the only ones available, which would you prefer?		☐	☐	☐

Figure 1. Example of choice set

Following a quota sampling design (Barnett 1991) on the six provinces of Andalusia with mountain olive groves we interviewed 353 citizens. The quota variables were sex, age, area of olive groves, province and town size. The last quota variable aimed to capture differences of valuation due to the urban/rural appreciations of the agricultural sector. The following table shows the expected and observed frequencies of the sample:

Table 2. Expected and observed frequencies of the quota sampling

Province	***<5.000 hab.***		***5.000-15.000***		***15.000-50.000***		***>50.000 hab.***		***Total***	
	Exp.	***Obs.***	***Exp.***	***Obs.***	***Exp.***	***Obs.***	***Exp.***	***Obs.***	***Exp.***	***Obs.***
Cádiz	1	1	1	1	11	15	17	11	*30*	*28*
Córdoba	9	7	13	15	15	11	26	26	*63*	*59*
Granada	15	14	8	3	4	3	26	30	*53*	*50*
Jaén	22	18	16	10	20	17	17	12	*75*	*57*
Málaga	6	9	11	16	18	20	33	35	*68*	*80*
Sevilla	4	5	11	17	16	18	33	39	*64*	*79*
Total	*57*	*54*	*60*	*61*	*85*	*84*	*152*	*153*	*353*	*353*

Source: Instituto de Estadística de Andalucía. Sistema de Información Multiterritorial de Andalucía. 2004.

The chi-square test does not reject the null hypothesis of non-difference between the sample and the population ($\chi^2_{calculated}$=23.8 < $\chi^2_{15, 0.05}$ = 25.0). Thus, from this point of view, we accept the sample as a fair representation of the target population.

Data codification

In the data analysis we dealt with quantitative variables (LANDSCAPE, EROSION, FOOD SAF. and KEEP POP.). For these kinds of variables we have applied two coding possibilities: (a) direct and linear continuous coding, and (b) the use of dummy variables. The former approach gives the average marginal willingness-to-pay (mean of individuals' implicit price of the attribute) for the range of variation considered, while the latter estimates the marginal propensity to change from the *status quo* situation to a certain level of the attribute. Since in our study we have opted for both approaches, it is possible to test whether or not the demand for non-market goods and services is convex, in correspondence with our common belief that increasing consumption of one good implies declining willingness-to-pay for that good, other things constant.

The end of the paper (see Appendix) carries a full description of the attribute coding, as well as the names of the variables employed in the models.

Econometric modelling

As most CE empirical studies suggest, the inclusion of socio-economic variables as explanatory variables tends to improve the predictive capabilities of the econometric model. Therefore, we opted for the following hybrid CL model specifications:

- **Model H1**: Hybrid CL model with ASC_j and S_{pn} interactions and continuous coding variables.
- **Model H2**: Hybrid CL model with *ASC* and S_{pn} interactions and dummy codification of the variables.

The socio-economic variables included in the analysis are: gender (SEX), age (AGE), household income (INC), education level (EDU), size of the population of the municipality (POP), household size (FAM), village of childhood (CHI) and knowledge of the agriculture of the area (KNO). All these socio-economic variables, except KNO, are included in the models as dummy variables, as shown in the Appendix.

Results

Multifunctional valuation of mountain olive groves

The following table shows the results for the whole population of the hybrid CL models with ASC_j and S_{pn} interactions (models H1 and H2).

At a 99% confidence level, we reject the null hypothesis that all coefficients are jointly or simultaneously equal to zero (significance of the Log-Likelihood Ratio – LLR– values). The goodness of fit of both models can be assessed through the McFadden's *pseudo*-R^2. In our case, the values are similar to those obtained in other empirical works (Boxall and Adamowicz 2002; Mazzanti 2003 or Mogas *et al*. 2005). Nevertheless, the H2 model yields slightly better results.

Table 3. Hybrid CL models with ASC and socio-economic variables interactions

Hybrid CL model with continuous coding variables (Model H1)				Hybrid CL model with dummy coding variables (Model H2)			
Variables	***Coeff.***	***St. Dev.***	***p-value***	***Variables***	***Coeff.***	***St. Dev.***	***p-value***
ASC	1.42	5.79×10^{-1}	0.0139	***ASC***	1.19	5.82×10^{-1}	0.0402
LANDSCAPE	1.85×10^{-2}	4.32×10^{-3}	0.0000	***LANDSCAPE1***	4.01×10^{-1}	8.71×10^{-2}	0.0000
EROSION	-7.79×10^{-2}	7.25×10^{-3}	0.0000	***LANDSCAPE2***	4.35×10^{-1}	9.02×10^{-2}	0.0000
FOOD SAF.	-3.56×10^{-3}	8.35×10^{-4}	0.0000	***EROSION1***	7.09×10^{-1}	8.73×10^{-2}	0.0000
KEEP POP.	-1.59×10^{-2}	2.15×10^{-3}	0.0000	***EROSION2***	9.90×10^{-1}	9.15×10^{-2}	0.0000
TAX	-2.97×10^{-2}	3.07×10^{-3}	0.0000	***FOOD SAF. 1***	2.35×10^{-1}	8.46×10^{-2}	0.0055
ASC×SEX	-8.37×10^{-1}	2.65×10^{-1}	0.0016	***FOOD SAF. 2***	3.84×10^{-1}	8.35×10^{-2}	0.0000
ASC×AGE1	-4.51×10^{-1}	2.40×10^{-1}	0.0598	***KEEP POP. 1***	7.44×10^{-1}	8.88×10^{-2}	0.0000
ASC×AGE2	-1.58	3.38×10^{-1}	0.0000	***KEEP POP. 2***	6.26×10^{-1}	8.93×10^{-2}	0.0000
ASC×INC1	2.41×10^{-1}	2.49×10^{-1}	0.3328	***TAX***	-3.29×10^{-1}	3.26×10^{-3}	0.0000
ASC×INC2	2.26×10^{-1}	3.81×10^{-1}	0.5524	***ASC×SEX***	-8.49×10^{-1}	2.65×10^{-1}	0.0014
ASC×EDU1	-2.20×10^{-1}	2.50×10^{-1}	0.3788	***ASC×AGE1***	-4.64×10^{-1}	2.40×10^{-1}	0.0537
ASC×EDU2	2.52×10^{-1}	3.20×10^{-1}	0.4311	***ASC×AGE2***	-1.60	3.39×10^{-1}	0.0000
ASC×FAM	2.31×10^{-1}	9.28×10^{-2}	0.0129	***ASC×INC1***	2.47×10^{-1}	2.49×10^{-1}	0.3219
ASC×POP1	6.59×10^{-1}	3.08×10^{-1}	0.0324	***ASC×INC2***	2.41×10^{-1}	3.82×10^{-1}	0.5279
ASC×POP2	3.11×10^{-1}	2.86×10^{-1}	0.2782	***ASC×EDU1***	-2.20×10^{-1}	2.51×10^{-1}	0.3798
ASC×CHI	-7.03×10^{-1}	2.90×10^{-1}	0.0154	***ASC×EDU2***	2.42×10^{-1}	3.21×10^{-1}	0.4512
ASC×KNO	3.80×10^{-2}	1.23×10^{-1}	0.7566	***ASC×FAM***	2.35×10^{-1}	9.29×10^{-2}	0.0116
				ASC×POP1	6.70×10^{-1}	3.08×10^{-1}	0.0298
				ASC×POP2	3.06×10^{-1}	2.87×10^{-1}	0.2855
				ASC×CHI	-7.09×10^{-1}	2.91×10^{-1}	0.0148
				ASC×KNO	4.60×10^{-2}	1.23×10^{-1}	0.7079
N	*1559*			***N***	*1559*		
LL(0)	*-1327.1*	***LL(θ)***	*-1174.4*	***LL(0)***	*-1327.1*	***LL(θ)***	*-1158.9*
LLR	*305.2 (0.000)*	***pseudo R^2***	*0.115*	***LLR***	*336.34 (0.000)*	***pseudo R^2***	*0.127*

N: number of observation.
LL(0): Log-likehood with ASC.
LL(θ): Log-likehood with all the variables.
LLR: Log-likehood ratio = -2(*LL(0)- LL(θ)*).

According to these results, all attributes are statistically significant; hence all the attributes considered are relevant determinants of social welfare. Moreover, in Model H1 all the attribute coefficients have the expected signs according to economic theory. Thus, the positive sign of the LANDSCAPE attribute implies higher levels of utility as the levels of this attribute increases. Conversely, the negative signs of EROSION, FOOD SAF. and KEEP POP. indicate reductions of utility in terms of soil loss, presence of residues in food and an increase in farm abandonment, respectively. Likewise, in Model H2 we reach the same conclusions, since the positive signs of all coefficients suggest an utility increase as the *status quo* situation changes toward states with moderate (level 1) and strong (level 2) levels of improvement.

The economic interpretation of these models can be obtained from the IP of the attributes, that is, the willingness to pay (WTP) for higher utility levels from changes in the attributes levels. Since these estimates are stochastic, the confidence intervals were calculated by using the Krinsky and Robb (1986) bootstrapping procedure from 1000 draws. The results appear in Table 4:

Table 4. Implicit prices and confidence intervals for each attribute (€/individual/year)

MODEL H1			***MODEL H2***		
Attribute	***IP***	***95% C.I.***	***Attribute***	***IP***	***95% C.I.***
LANDSCAPE	0.62	(0.30 ; 0.98)	***LANDSCAPE1***	12.20	(6.80 ; 18.21)
EROSION	-2.62	(-3.48 ; -1.95)	***LANDSCAPE2***	13.21	(7.10 ; 19.91)
FOOD SAF.	-0.12	(-0.18 ; -0.06)	***EROSION1***	21.55	(15.36 ; 29.26)
KEEP POP.	-0.53	(-0.75 ; -0.38)	***EROSION2***	30.11	(22.95 ; 40.27)
			FOOD SAF.1	7.14	(2.00 ; 12.52)
			FOOD SAF.2	11.66	(6.47 ; 17.90)
			KEEP POP.1	22.61	(16.23 ; 30.23)
			KEEP POP.2	19.03	(13.15 ; 26.06)

Note: IP in model H1 are measured in €/individual/year, accounting for a marginal increase (one unit more) in the attribute considered. In model H2, IP are also measured in €/individual/year, but in this case the amount reported is the willingness-to-pay for changing from the *status quo* situation to a certain level of the attribute.

In order to compare the results from both models the reader should bear in mind the differences in the interpretations of the various regressors: in model H1 (continuous coding) they represent a marginal increase in utiility from one extra unit of the attribute; in model H2 (dummy coding) the regressors correspond to the utility improvement due to changes from the *status quo* situation to the proposed levels of improvement of each attribute.

All implicit prices in Table 4 are statistically different from zero. According to the results in Model H1, people in Andalusia are thus WTP on average €0.62/year for an increase of 1% in other fruit trees than olives to improve the visual quality of the mountain landscape, €2.62/year for 1 tonne of soil loss lower that the current level, €0.12/year for a 1% reduction of the current level of residues in food and €0.53/year for a 1% reduction of the expected level of farm abandonment. This proves that agricultural multifunctionality is actually demanded by the public. These differences in implicit prices offer some indication of the general public's preferences for particular aspects of agricultural multifunctionality.

From the results of Model H2 Compensating Surplus (CS) welfare measure can be obtained for different scenarios associated with multiple changes of attributes, using the equation proposed by Hanemann (1984):

$$CS = -\frac{\ln \sum_k e^{V_{k1}} - \ln \sum_k e^{V_{k0}}}{\beta_m} = -\frac{V_0 - V_1}{\beta_m} \qquad (7)$$

where V_0 is the utility for the status quo alternative, V_1 represent the utility of the proposed scenario change and β_m is the estimated parameter of the monetary attribute.

Using the above calculation, the WTP for the moderate improvement from the current situation (i. e. changes to LANDSCAPE1, EROSION1, FOOD SAF.1 and KEEP POP.1) and the further one (changes to LANDSCAPE2, EROSION2, FOOD SAF. 2 and KEEP POP.2) has a WTPs of 63.50 and 74.01 €/individual/year, respectively. Likewise, the WTP for any combination of improvements in the level of attributes can be obtained. Thus, multiplying the individual implicit prices obtained by the whole population (5,664,580 Andalusians above the age of 18, according to 2001 census), we reach an aggregate WTP of 359.70 and 419.24 MEur, respectively. In order to put these figures into perspective, it is worth mentioning that the EU expenditure of the olive oil Common Market Organization on this type of olive grove is only 80.13 MEur.

The results of Model H2 also allow the convexity of the demand for positive externalities (decreasing marginal WTP) to be verified. If so, it should be demonstrable that $\frac{IP_{O\to1}}{level_1 - level_O} \rangle \frac{IP_{O\to2}}{level_2 - level_O}$, i.e., the marginal WTP to change from the current attribute level 0 (*status quo*) to level 1 should be higher than the marginal WTP to change from level 0 to level 2. The results shown in the following table confirm this point.

Table 5. Validation of convex demand curve for multifunctional attributes

Quantitative attributes	$\frac{IP_{O\to1}}{level_1 - level_O}$	$\frac{IP_{O\to2}}{level_2 - level_O}$
LANDSCAPE (Level$_0$: 0% other fruit trees)	*1.22 € / 1% increase other fruit trees* (Level$_1$: 10% other fruit trees)	*0.66 € / 1% increase other fruit trees* (Level$_2$: 20% other fruit trees)
SOIL EROSION (Level$_0$: 13 ton/ha.year)	*2.69 € / ton.ha.year* (Level$_1$: 5 ton/ha.year)	*2.51 € / ton.ha.year* (Level$_2$: 1 ton/ha.year)
FOOD SAF. (Level$_0$: Current level of residuals)	*0.14 € / 1% reduction* (Level$_1$: 50% reduction)	*0.12 € / 1% reduction* (Level$_2$: 100% reduction)
KEEP POP. (Level$_0$: 50% farm abandonment)	*0.90 € / 1% farm abandonment lower* (Level$_1$: 25% farm abandonment)	*0.48 € / 1% farm abandonment lower* (Level$_2$: 10% farm abandonment)

Heterogeneity of public preferences

Using the interactions between ACS and the socio-economic variables in the hybrid CL models H1 and H2 enable us to assess the overall valuation of multifunctionality depending on the socio-economic characteristics of the respondents. Thus, women (SEX=0) value more than men the multifunctionality of these agricultural systems (i.e. the whole set of attributes included in the models). Likewise, young people, large families, people living in large cities and/or brought up in rural areas are more in favour of the provision of these public goods.

Conversely, income level was not significant, indicating that the attributes considered in the multifunctional analysis do not exhibit high-income elasticity (or "luxury goods" in the economics literature) and suggesting an income elasticity lower than one, as Kriström and Riera (1996) point out for other environmental public goods. According to these authors, low-income populations value this type of goods more highly, whereas their high-income counterparts have easier access to these goods away from local agricultural systems, and therefore tend to diminish their valuation.

Overall, these results indicate that there is a wide heterogeneity in the demand for multifunctional agriculture, depending on certain socio-economic characteristics of the respondents.

Conclusions

The main finding of this study is the identification of a social demand for public goods and services provided by the agricultural sector, considering mountain olives groves as case study: 0.62 €/hab.year for 1% increase in other fruit trees hectarage (improving the visual quality of the landscape), 2.62 €/hab.year for a soil loss reduction of 1 tonne/ha.year (contributing to the sustainability of the agricultural system), 0.12 €/hab.year for each unit of reduction of the residual substances in the olive oil (ensuring food safety) and 0.53 €/hab.year for 1% reduction of farm abandonment (preventing rural depopulation in mountain areas). This support for agricultural multifunctionality is in any case heterogeneous inside the society: i.e. citizens' valuation of the whole notion of multifunctionality and the various attributes that the concept involves.

The results suggest that, taking into account the impact of an overall improvement in the attribute levels, women, people with a higher level of education, the urban population and families with more than three members are those who benefit most from the provision of public goods by agriculture.

Finally, we would like to remark the practical implications of the present study for the design and implementation of agricultural policies in this sector. The results on the society's valuation of the different externalities provided by this agricultural system enable us to improve de policy decision making in order to optimize the social welfare of the citizens. Thus, although the new orientation of the CAP which makes decoupled payments conditional on compliance with a range of environmental, food safety, animal and plant health and animal welfare standards will presumably promote a net increase in social welfare, based on the results of this research, some measures could be introduced to maximize the aforementioned welfare, namely: the increase of crop variety (to improve the visual quality of the landscape), the use of grass cover in olive groves (to reduce soil loss), the prevention of farm abandonment (to minimize rural depopulation) and the promotion of either organic or integrated production (to ensure food safety).

Notes

[1] The mathematical requirements of additive utility functions can be found in Fishburn (1982) and Keeney and Raiffa (1993). From a practical point of view, the main condition is utility independence of the attributes. Although this assumption is rather strong and is considered responsible of over estimation of the economic values of environmental goods (Hoehn 1991), many authors (Edwards 1977; Farmer 1987; Huirne and Hardaker 1998) consider the additive utility function and acceptable approximation to the true utility functions even under non-utility independence of the attributes.

[2] In case of choice sets defined as labelled alternatives, the appropriate approach is to consider different ASC for each alternative (*Status quo*, Alternative A and alternative B). However, when the alternatives are generic (unlabelled alternatives) it can be assumed that $ASC_{status\ quo}=0$ and $ASC_{alternative\ A}=ASC_{alternative\ B}$ (Bennett and Adamowicz 2001, p.60; Mazzanti 2003), as this paper presents.

[3] Many studies consider exclusively main effects since they account up to 90 per cent of the total variance of the dependent variable (Dawes and Corrigan 1974). Furthermore, the interactions between variables represent less than 2-3% of the total variance (Louviere 1998). Hence, it is common, as in the present study, to exclude these interactions and focus on main effects (Louviere *et al*. 2000).

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APPENDIX

Definition and coding of the variables in the models

Variable	Description
Landscape and preservation of biodiversity	
Continuous coding	
LANDSCAPE	Percentage olive groves covering the agricultural area
Dummy coding	
LANDSCAPE0	Baseline: 0% of other fruit trees (*status quo*)
LANDSCAPE1	Equal 1: 10% other fruit trees; Equal 0: otherwise
LANDSCAPE2	Equal 1: 20% other fruit trees; Equal 0: otherwise
Soil erosion	
Continuous coding	
EROSION	Soil erosion in tons per hectare and year
Dummy coding	
EROSION0	Baseline: 13 ton/ha.year (*status quo*)
EROSION1	Equal 1: 5 ton/ha.year; Equal 0: otherwise
EROSION2	Equal 1: 1 ton/ha.year; Equal 0: otherwise

Food safety	
Continuous coding	
FOOD SAF.	Level of residuals in the olive oil
Dummy coding	
FOOD SAF.0	Baseline: Current level of residuals from conventional agriculture (*status quo*)
FOOD SAF.1	Equal 1: 50% reduction (integrated agriculture); Equal 0: otherwise
FOOD SAF.2	Equal 1: 100% reduction (organic farming); Equal 0: otherwise
Keeping rural population in their villages	
Continuous coding	
KEEP POP.	Reducing farm abandonment to avoid rural depopulation
Dummy coding	
KEEP POP.0	Baseline: 50% farm abandonment (*status quo*)
KEEP POP.1	Equal 1: 25% farm abandonment; Equal 0: otherwise
KEEP POP.2	Equal 1: 10% farm abandonment; Equal 0: otherwise
Extra cost for the improvements of the alternatives	
Continuous coding	
TAX	Levy on income tax
SOCIOECONOMIC VARIABLES	
Sex (SEX)	Equal 1: male; Equal 0: female
Age	
AGE0	Baseline: 18-34
AGE1	Equal 1: 35-54; Equal 0: otherwise
AGE2	Equal 1: Older than 54; Equal 0: otherwise
Monthly family income	
INC0	Baseline: lower than 1.500 €/month
INC1	Equal 1: between 1.500 and 3.000 €/month; Equal 0: otherwise
INC2	Equal 1: Higher than 3.000 €/month; Equal 0: otherwise
Education level	
EDU0	Baseline: Primary
EDU1	Equal 1: Secondary; Equal 0: otherwise
EDU2	Equal 1: University; Equal 0: otherwise
Family members	
FAM	Number of family members
Town size	
POP0	Baseline: less than 15.000 inhabitants
POP1	Equal 1: between 15.000 and 50.000 inhabitants; Equal 0: otherwise
POP2	Equal 1: more than 50.000 inhabitants; Equal 0: otherwise
Childhood origen	
CHI	Equal 1: childhood in rural areas; Equal 0: childhood in urban areas
Knowledge of agriculture	
KNO	Likert scale from 1 (little knowledge) to 5 (very high knowledge)