Instituto Nacional de Investigación y Tecnología Agraria y Alimentaria (INIA)
Disponible on line en www.inia.es/srf
Investigación Agraria: Sistemas y Recursos Forestales 2009 18(3), 235-246
ISSN: 1131-7965

Estimating the social benefits of recreational harvesting of edible wild mushrooms using travel cost methods

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Abstract

The public demand for recreational harvesting of edible wild mushrooms has risen over the last two decades and currently affects all forestry areas with mycological resources in Spain. The idea of introducing a system of 'user-pays' fees has been conceived as a possible ecosystem management strategy. Valuing the recreational benefits people derive from harvesting edible wild mushrooms may provide some guidance as to how much people would be willing to pay and may also justify future taxes for on harvesters. Environmental valuation methods allow the benefits of this recreation activity to be estimated. In this case, the authors estimate a demand model of recreational harvesting of edible wild mushrooms in '*Pinar Grande'* (Soria, Spain) through the zonal travel cost model, its consumer surplus associated and explanations factors.

Key words: Recreational harvesting of edible wild mushrooms, zonal models, estimated consumer surplus.

Resumen

Estimación de los beneficios sociales de la recolección recreativa de setas silvestres comestibles a través del método del coste del viaje

La demanda de recolección de setas silvestres comestibles ha crecido de forma importante en las últimas décadas afectando en España a todas las áreas con recurso. La idea de introducir un sistema de pago de permisos ha sido concebida como una posible estrategia de regulación del ecosistema. Valorando los beneficios recreativos que genera esta actividad, a través de métodos de valoración ambiental, se podría conocer lo que los recolectores estarían dispuestos a pagar y justificar así la imposición sobre este recurso. En el presente artículo, los autores estiman un modelo de demanda de recolección recreativa de setas silvestres comestibles en "Pinar Grande" (Soria-España) utilizando el método del coste del viaje en su versión zonal. A partir de aquí, se calcula el excedente del consumidor asociado junto con sus factores explicativos.

Palabras clave: Recolección recreativa de setas silvestres comestibles, modelos zonales, excedente del consumidor estimado.

Introduction

The public demand for recreational harvesting of edible wild mushrooms has risen over the last two decades and currently affects all forestry areas with mycological resources in Spain, impacting on private and public forest landowners. Despite its growing social and economic importance as a forestry resource (Díaz Balteiro *et al*., 2003; Martínez Peña, 2003), the harvesting of wild mushrooms continues to be overlooked in forestry management.

Various authors have investigated into the management of mycological resources (Fernández, 1994; Hosford *et al*. 1997; Palm y Chapela, 1997; Martínez

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Received: 04-02-09. Accepted: 04-11-09.

Peña, 2003, etc.). The idea of introducing a system of 'user-pays' fees, therefore, has been conceived as a possible solution. Since 2003, edible wild mushroom harvesting has been regulated in the forests of the Castilla y León region. In 2006, 60,630 hectares were regulated using the methodology explained below. The regulation of mushroom harvesting is carried out by signposting the areas of harvesting with notices stating where to collect or not, vigilance of harvesters, commercial control and harvester licences ('user-pays' fees).

In forests which are regulated, it is therefore necessary to hold a mushroom harvest licence. This licence could be valid for a day or a year and with two different kinds of licence to choose from according the harvest activity: a recreational harvest licence (for quantities of mushrooms harvested below 3 kg) or a commercial harvest licence (unlimited quantities).

The price for a recreational and daily harvest licence is 5 €. Whereas, the price for a recreational and annual harvest licence is variable, according to the region where the harvester has come from. However these recreational licence prices are not related to the demand generated by harvesters, due to the fact that these functions have not been estimated through environmental valuation methods. These techniques allow the benefits of this recreation activity to be used as guidance for policy makers. Valuing the recreational benefits derived from the harvesting of edible wild mushrooms may provide some guidance as to how much harvesters would be willing to pay and may justify future taxes.

Therefore, the object of this paper is to provide a recreational demand analysis of non-commercial mushroom harvesting in the '*Pinar Grande*', using travel cost methods.

A wide selection of empirical literature is available on outdoor recreation demand (Brouwer and Spaninks, 1999; Rosemberg and Loomis, 2001; Morrison *et al*., 2002; Amjath and Suryaprakash, 2008; etc.). Much has also been written about "non-timber values" (Balkan and Kahn, 1988; Layman *et al*., 1996, Knoche and Lupi, 2007; etc.) focusing mainly on the recreational aspects of hunting and fishing. Unfortunately this literature lacks estimates of edible wild mushroom harvesting (Starbuck *et al*., 2004). Spain also has a wide array of literature on forest recreation aspects (Riera, 1997; Riera, 2000; García y Colina, 2004; Mogas, *et al.*, 2005; etc.), but few studies focusing on "non-timber values" (Martínez Peña, 2003 and Martínez de Aragón, 2005).

Materials and methods

Description of study area

The study area is located in a public forest known as '*Pinar Grande*', which covers an area of 12,533 hectares. This forest is situated in the northern part of Sistema Iberico mountain range, in the region of "Pinares" (Soria). The study area is comprised of pure Scots pine (*Pinus sylvestris* L.) stands and small stands mixed with *Pinus pinaster* Ait., *Quercus pyrenaica* Wild. or *Fagus sylvatica* L. The most representative genera for biomass of epigeus macromycetes are: *Russula* (25.8 %), *Suillus* (21.1 %), *Boletus* (15.8 %), *Amanita* (8.5 %), *Pholiota* (5.8 %), *Cortinarius* (5.6 %) y *Tricholoma* (3.8 %) (Martínez Peña y Fernández, 1999). The most harvested species are *Boletus* gr. *edulis* and *Lactarius* gr. *deliciosus* (García Cid, 2002).

'*Pinar Grande*' has been managed since 1907, although nowadays it is mainly exploited for timber. Even though timber cutting and cattle can modify mushroom production, these do not disturb mushroom harvesting. However, mushroom harvesting is prohibited during the hunting season. Mushroom harvesting is not considered with sufficient detail in Pinar Grande management plans, despite its social and economic importance. In fact, mushroom harvesting could represent 6% of the value of timber, which collects income of €9 per hectare, even without taking into account the recreational value generated by mushroom harvesting (Martínez Peña, 2003). Other management alternatives show that the net present value generated by mushroom harvesting could be 40 % of the value obtained by timber cutting (Aldea, 2009).

Currently, the landowner of "Pinar Grande" does not obtain any income from mushroom harvesting and neither is it included in the regulated areas with harvesting licences, however this may change in future.

Methods

The travel cost model (TCM) of estimating the demand function has been applied to a wide range of recreational activities including hunting, fishing and forest recreation (Ward and Beal, 2000). The TCM is the approach selected to estimate the consumer surplus associated to recreational harvesting of edible wild mushrooms in '*Pinar Grande*'. Firstly, it is one of the most popular valuation techniques in measuring the value of a non-market resource (Inhyuck, 2007). Secondly, its application is cheaper than other methods, in particular contingent valuation methods and this reason is particularly important in situations such as this one which do not have financial backing.

This method has been developed from a suggestion made by Hotelling (1947) in a publication on the economist recreation in US national parks by the National Park Service. Hotelling suggested using the travel cost incurred by an individual when visiting a recreation site as an implicit price for the services of that site. Exploiting the empirical relationship between increased travel distances and associated declining visitation rates would permit one to estimate the demand relationship. In this way, the Marshallian demand curve for the recreation service can be estimated and appropriate consumer surplus measures calculated and thus provide a basis for comparing them with the cost of their supply.

Two major variants of the TCM are the zonal travel cost method (ZTCM) and the individual travel cost method (ITCM). A general reduced-form demand function relates visitation rates (VI) to travel cost (TC) and other relevant variables (X_i) and can be specified as:

$$VI_i = \alpha + \beta_1 TC_i + \beta_2 X_{2i} + \beta_3 X_{3i} + \cdots + \varepsilon_i \qquad [1]$$

Where α is the intercept, the β'_s are the regression parameters and ε_i is the error term indicating each zone or individual (Perman *et al*, 2004).

In the ZTCM, the area surrounding the recreation site is divided into various zones. Each zone has an average travel cost according to its distance from the site (Garrod and Willis, 1991). The visitation rate per zone, in a given time period, can be estimated using the average travel cost. Several authors have applied this version to estimate the demand relationship (English and Bowker, 1996; Bateman *et al.,* 1999; Bennear, 2005; Inhyuck, 2007). Various Spanish authors have also written on this subject (Campos and Riera, 1996; Martínez Peña, 2003; Riera y Farreras; 2004).

However, this approach has two important limitations (Ward and Bell, 2000). Firstly, there is the difficulty in accounting for the effects of travel time on individuals, since there is a high correlation between travel cost and travel time when individual experiences are averaged to estimate zonal values. In order to overcome multicollinearity in the regression analysis, travel time must be omitted. Secondly, the aggregation and averaging process required to estimate zonal values make certain demand determinants, particularly the socioeconomic variables, statistically non-significant. In effect, there is a loss of information efficiency.

The ITCM on the other hand, uses survey data from individual visitors to link the demand of natural resources to its determinants. These include how far the visitor must travel to get to the site, the amount of time spent travelling, travel and on-site expenses, their income and other socioeconomic characteristics, etc. Therefore, this method allows the amount of visits purchased at different prices to be calculated. The two advantages to the ITCM are that it follows conventional methods used by economists to estimate economics values based on market prices and also relies on what people actually do rather on what people say they would do in hypothetical situations (Bell and Leeworthy, 1990). Due to these reasons and to the weak theoretical foundation of the behavioural patterns in the aggregate demand models, this version is preferred over the ZTCM (Bhat *et al.*, 1998; Buchli *et al.*, 2003; Nillesen *et al.* 2005, etc. and Pérez y Pérez *et al.*, 1998; Riera, 2000; García and Colina; 2004, etc. in Spain), but in any case, economic theory shows individual models to be superior to zonal models (Fletcher *et al.*, 1990).

In this sense, empirical studies provide mixed results. For example, the ZTCM is considered more appropriate to estimate consumer surplus when visits are uniformly distributed and ITCM is more suitable for the case for multiple-destination due to the difficulty of obtaining the site-specific travel cost estimates (Cook, 2000). Given the availability of data and simplicity of application, the zonal approach has been used in this study. This methodology uses relatively straightforward demand models that, given certain research objectives, can indeed perform as well as individuals models (Hellerstein, 1995). We believe that this approach is suitable because the visits are uniformly distributed among Spanish provinces and recreational harvesting is the only reason to visit Pinar Grande in the autumn season (see data).

However, there are a number of problems that may arise in the implementation of the TCM. Two of them are briefly discussed here. The first is the choice of functional form used in the estimation of the demand curve. The economic theory of constrained optimisation with weak complementarity does not imply any particular functional form for the trip generating equation. Given no *a priori* guidance, the functional form is decided according to which fits the data better. This decision has important implications for the results obtained and affects both the expected value and variance of consumer surplus estimates (Ziemer *et al*., 1980; Hanley, 1989; Adamowicz *et al*., 1989; Hellerstein, 1991; Ozuna *et al*., 1993).

Three functional forms were used to estimate the econometric model of visitor demand; linear, semilog, and exponential specification functions. Linear models are the most commonly used to estimate using ordinary least square (OLS) regression. None of the variables need to be transformed, thus minimising potential coding errors. They are also easy to interpret for policy makers investigating visitor rates. However, linear models have been less popular during the last 20 years of published research in TCMs because the goodness of fit is worse than nonlinear forms (Ward and Bell, 2000). This is particularly the case where there are few visits at very high prices and many visits at near-zero prices. In our case, linear function had the least adjusted R^2 compared to the other two models so we rejected this approximation. Semi-log models, where the dependent variable is transformed by taking the natural logarithm, are commonly used in literature such as Ziemer *et al*. (1980), Vaughan *et al*. (1982), Strong (1983) or Willis and Garrod (1991). This specification shows the best adjusted R^2 , however, the test for the present of heteroscedasticity rejects the null hypotheses of homocedasticity, which would bias the estimates of parameters variance and lead to incorrect statistical conclusions, and therefore, we also rejected this specification. The third specification presents the second best adjusted R^2 after the semi logarithmic model and thus the exponential specification for the Clawson and Knetsch model was selected.

The second widely discussed aspect of TCM is the specification of the monetary price of recreation trip. There are four kinds of travel cost that could be used in a TCM study: petrol cost; full car running cost; out-of-pocket cost; and travel time cost, as well as the added decision for the investigator in determining which the part of the total travel cost to consider when a person or a family visits several sites during the trip.

In order to minimize the effect of the monetary travel cost specification on the estimated welfare measures only petrol cost is taken as an approximation of the travel cost. Although not common practice, it is a more cautious measure. If the obtained measures are to be used as a guide in making forest policy decisions, these values would need to be the most cautious possible and cannot be seen to be influenced by the decisions taken by the investigator (Randall, 1994).

The following demand function was estimated for all years between 1997 and 2005 as follows:

$$Ln(VI_i) = \alpha + \beta_1 * {}^{1}\!/_{TC_i} + \beta_2 * GDPpc_i + \beta_3 * MS_i + \varepsilon_i \quad [2]$$

Where i-zones are Spanish provinces, equivalent to two digits statistical division of National Statistics Institute (Spanish Statistical Office). VI_i are the visitation rates of area i, defined as visitation per 1,000 inhabitants and were calculated using the following formula:

$$VI_i = \frac{V_i * 1000}{P_i} \quad [3]$$

TC_i are the vehicular travel costs based on average running petrol costs per kilometre between the capital of area i and the study site. It is expected that this variable would be negative, in the sense showed by the economic theory. $GDPpc_i$ are the per capital gross domestic product of the i areas, used to display the effect of level income on the demand function. Therefore, the expected sign of this variable would be positive in the sense shown by the economic theory. MS_i are the number of mycological societies in the i areas and could be used to show the preferences of the inhabitants of these areas in the recreational harvesting of edible wild mushrooms. The expected sign of this variable would be positive in the sense shown by the economic theory.

The initial models included the migration rates of i zones (MR_i), defined as the percentage of persons of i areas who were born in Soria. This variable could shows the importance of these people born in Soria who return to the study area every year in picking season as they did when they lived in Soria. However, this variable is correlated with the distance and, therefore, with the cost of the trip, generating multicollinearity problems. Therefore, this variable was eliminated from the demand equation. The explanatory reasons for this behaviour are that the population emigrates to nearest provinces.

The estimated travel costs regression coefficients can be used to determine the value of recreational harvesting of edible wild mushrooms in '*Pinar Grande'* in terms of consumer surplus in any year. Using an evaluation technique, often known as the Hotelling-Clawson approach, the travel cost coefficient is used as a measure of sensitivity of participants to added cost, such as a harvest fee (Clawson and Knetsch, 1966). If *hf* is the added cost, equation [2] becomes:

$$\frac{\hat{V}_i * 1000}{P_i} = e^{\hat{\alpha} + \frac{\hat{\beta}_1}{(TC+hf)_i} + \varepsilon_i} \quad [4]$$

Where $\hat{V}_i$ is the estimated numbers of annual trips from area *i* to *Pinar Grande* and $\hat{\alpha}$ and $\hat{\beta}_1$ the estimated regression parameters. We can refer to the relationship in equation [4] as the Marshallian or *uncompensated* demand curve which includes the income effect of a price change. Integrating this equation for each year, results in an estimate of the annual Marshallian consumer surplus (MCS) in the absence of a harvest fee[1]. The maximum willingness to pay every year for the area under the travel cost derived demand curve (Anex, 1995) is calculated. This estimation could be an accurate approximation of the individual recreational harvester's welfare under the assumption of a free access situation. Equation [4] can be integrated as follows:

$$MCS = \int_{atc}^{mtc} e^{\hat{\alpha} + \frac{\hat{\beta}_1}{TC}} dTC \qquad [5]$$

Where *atc* is the weighted average actual travel cost in every year and *mtc* is the cost at which no trips are demanded, also known as the chock price. Given the characteristics of the estimated demand function, the chock price would be infinite. The calculation of the Marshallian consumer surplus would not be possible using an infinite price chock. In order to solve this problem travel cost was replaced by the maximum cost possible to access the zone from within Spain. This decision has been justified by it being improbable that trips are demanded from a greater distance.

The mathematical solution of the integration process returns the following formula (see appendix) to calculate the MCS of recreational harvesting of edible wild mushrooms in '*Pinar Grande'*:

$$MCS = e^{\hat{\alpha}} \left\{ (mtc - atc) + \hat{\beta}_1 \ln \frac{mtc}{atc} + \sum_{n=0}^{\infty} \left[\frac{\hat{\beta}_1^{\,n+2}}{(n+2)*(n+1)} * \left(\frac{1}{atc^{n+1}} - \frac{1}{mtc^{n+1}} \right) \right] \right\} \qquad [6]$$

Finally, we tested the explanation factors of the Marshallian consumer surplus in every year adjusting the following equation using OLS regression:

$$Ln(MCS_t) = \alpha' + \beta'_1 * BEFP_t + \beta'_2 * BEFP_{t-1} + \beta'_3 * CP_t + \varepsilon_i \qquad [7]$$

Where t are the years between 1997 and 2005. MCSt are the estimated Marshallian consumer surplus in every year, and $BEFP_t$ are the fit production in kilogrammes per hectare of the most important species harvested in *'Pinar Grande'* (*Boletus edulis*) in every year. The expected sign of this variable would be positive, in the sense of bigger harvests: greater satisfaction. $BEFP_{t-1}$ are the retarded fit production in kilogrammes per hectare of the most important species harvested in *'Pinar Grande'* (*Boletus edulis*) in every year. The expected sign of this variable would be positive because harvesters could travel to the study area expecting find it in the same condition as the previous year. CP_t are the cost of petrol in every year. The expected sign of this variable is indeterminate and depend on demand elasticity-price of equation 2. If petrol cost was to change, it could impact on the number of visits, the sign would be negative and vice versa.

The initial model included the number of mycological societies in Spain in every year (MS_t). However, this variable was correlated with the cost of petrol (CP_t), generating multicollinearity problems[2]. This variable was eliminated of the analysis.

Data

Aggregation (i areas) was selected on a provincial level for two reasons. Firstly, the sample plates only were available in this disaggregation level and, therefore, it was the only way to get the dependent variable V_i. Secondly, in Spain there is no reliable statistical information to lower aggregations, except on a municipal level, but disaggregation occurs to such an extent that it does not respond to the focus of the study. Higher aggregation was possible at one digit statistical division of National Statistics Institute (Spanish Statistical Office) equivalent to Autonomous Communities level, but this aggregation was rejected due to the loss of information efficiency. Spain has 52 provinces, the autonomous cities of Ceuta and Melilla included. Five of them were eliminated because is not possible travel to the study site by car.

The total visitation of recreational harvesting of edible wild mushrooms per zone data (V_i) were collected by the Department of Forestry Investigation, Valonsadero (a department dependent on the regional government), in the study area from 1997 to 2005. This data was obtained from weekly surveys on forest tracks accessible to vehicles randomly selected in the '*Pinar Grande'* forest. The surveys counted the number of parked vehicles belonging to harvesters and their

[1] The hicksian compensating variation and equivalent variation welfare measures are the theoretically correct measures of the value of the benefits, even though Willig (1976) showed that consumer surplus is an acceptable approximation.

[2] These variables have a growing trend during the study period.

province of origin according to the number plates. The sampling was always performed following the same pattern, starting and finishing at the same time of day, covering the 16 forest tracks (29.5km of the total 96.5km of forest tracks accessible in the forest). The sampling was carried out on a weekly basis throughout the autumn every year from 1997 through to 2005, totalling 126 samples. Each sample allowed for an estimation of the average number of harvesters per kilometre of forest path per day from each province of origin. Multiplying this figure by the total 96.5km (of forest tracks), the total number of harvesters per day who had travelled from each different place was calculated for the whole of '*Pinar Grande'* (Ortega-Martínez, 2005).

Although the mushroom harvesting takes place in spring and autumn, only autumn was considered for the inventory of production and vehicles as this season is the most important in terms of production and harvester activity. In any case, the sample was considered sufficiently representative because it takes into account 30 % of the total forest tracks in the areas with poor accessibility and lower quality of mushroom production. Moreover, when the number plates of the vehicles were insufficient to ascertain the origin of vehicle, the distinguishing dealership sticker was used.

All of the vehicles belonged to mushroom harvesters, because according to vehicle surveys for this area during the year, vehicles are only observed when harvesting of edible wild mushroom occurs in autumn.

Commercial harvesters were eliminated from the analysis of annual samples using data from the Department of Forestry Investigation, Valonsadero. The percentage of commercial harvesters was extracted from the total number of harvesters in terms of their province of origin.

The vehicular travel costs (TC_i) were calculated for a range of different types of cars under the assumption that the type of vehicle a person owns and the price of the petrol does not depend on the zone of origin and that costs per kilometre are the same across all zones. For each year, the weighted-average running cost in current euros was calculated using data from the Minister of Industry, Tourism and Trade on distances and prices of petrol (MITT, 1997-2005).

The population per zone i (P_i) and per capita domestic gross product of i zones ($GDPpc_i$) were collected of the National Statistics Institute (NSI, 1997-2005).

The number of mycological societies in i zones (MS_i) were collected from several sources like mycological publications, association web sites, regional governments requests, etc.

Finally, the fit productions in kilogrammes per hectare of the most important species harvested in 'Pinar Grande' (Boletus edulis), $BEFP_t$ and $BEFP_{t-1}$, were collected in the study area during the period 1997-2005 (Martínez Peña, 2009).

Results

The results of the ordinary least squares estimation of the demand models described by equation [2] for all years are presented in Table 1 and 2.

The models were evaluated using several criteria, including explanatory power (adjusted R^2) and significance (F-value). In the first case, the explanatory power is very high for all years with adjusted R^2 between the values of 0.623 (2005) and 0.823 ((2001). In the second case, F-ratio value indicated that all models were significant overall at the 1% level, except for 2005, significant at the 5% level.

With respect to the price or travel cost coefficients estimates for each of the nine annual models, were consistent with demand theory, in that the quantity of visitors per 1000 inhabitants in the area was inversely related to price or travel cost. Intercept and travel cost coefficients are significant at the 1% level for all years, except 2005 travel cost coefficient that is significant at the 5% level. In relation to other coefficients, the major limitation of ZTCMs is the loss of data variation due to zonal averaging that results in insignificant social and demographic variables (Poor and Smith, 2004), as in this case. For example, provincial per-capita income only was significant in three years, one at 1% level (2002), one at 5% level (1998) and one at 10% level (2001). On the other hand, the sign of these coefficients is positive and is the expected according to consumer behaviour (except in 2005). However, the number of mycological societies was insignificant for all years and it sign is negative which goes expectations.

The models were tested for heterodedasticity because travel cost models with unequal populations often lack homocedasticity, which is caused by the difference in visitation rates from zones with larger populations being greater than in zones with smaller populations (Bowes and Loomis, 1980; Vaughan *et al*., 1982). This problem is also common when there are variations in visitation rates between zones (Christensen and Price, 1982). The correlation between dependent variable predicted adjusted values and standardised residuals regression, using Pearson's correlation coefficient,

Table 1. Ordinary least squares estimates for recreational harvesting of edible wild mushrooms in *'Pinar Grande'* (Soria-Spain): summary models and Marshallian consumer surplus

YEAR	R	R^2	Adjusted R^2	F	Sig (99%)	Durbin-Watson	Pearson´s correlation coefficient	Kolmogorov Smirnov (Z)	atc (weighted)	mtc	MCS
1997	0.850	0.722	0.667	13.013	YES	1.830	-0.048	0.661	27.29	356.82	**18.84**
1998	0.901	0.812	0.775	21.612	YES	2.256	-0.075	0.629	19.88	356.82	**27.36**
1999	0.853	0.728	0.680	15.15	YES	1.665	-0.058	0.348	27.30	356.82	**21.27**
2000	0.926	0.857	0.803	15.981	YES	1.981	-0.096	0.698	25.64	356.82	**18.11**
2001	0.923	0.853	0.823	28.979	YES	1.679	-0.077	0.653	25.39	356.82	**28.81**
2002	0.898	0.806	0.773	24.856	YES	2.270	0.434	0.406	25.32	356.82	**22.53**
2003	0.850	0.722	0.673	14.751	YES	2.305	-0.076	0.574	24.50	356.82	**28.07**
2004	0.918	0.842	0.809	24.951	YES	1.953	-0.064	0.52	26.20	356.82	**15.42**
2005	0.836	0.698	0.623	9.254	YES (*)	2.010	-0.244	0.407	18.73	356.82	**12.23**

(*) Significant at the 95% significance level. Source: own elaboration.

was insignificant at the 95% significance level. Heterodedasticity is not, therefore, considered to be a problem for this analysis.

The models were also tested too for autocorrelation, using the Durbin-Watson test, and residuals normality absence[3], using Kolmogorov-Smirnov test with the standardised residuals sample. In all years the applied test rejected the presence of these problems, and so the models are believed to be valid for prediction making and the Marshallian consumer surplus is calculated in terms expressed in formula number 6.

The results of the integration process, between actual and maximum travel cost (*atc* and *mtc*), for all years are presented in final columns of Table 1. The range of the consumer surplus varies between the 12.23€ per car in 2005 (minimum MCS) to 28.81€ per car in 2001 (maximum MCS) where the average of the period reaches a value of 21.40€.

According to face to face surveys conducted in the autumn seasons in Pinar Grande (García Cid, 2002), the average number of people per local car was 2.02 (1.8 adults and 0.22 children) and 2.57 per car coming from outside of Soria (2.29 adults and 0.28 children). The weighted average per car in the period 1997-2005 is 2.28[4] (2.03 adults and 0.25 children). The consumer surplus per harvester varies between

Table 2. Ordinary least squares estimates for recreational harvesting of edible wild mushrooms in *'Pinar Grande'* (Soria-Spain): demand parameters

YEAR	A				β_1				β_2				β_3			
	Value	Standard error	t-value	Sig (99%)	Value	Standard error	t-value	Sig (99%)	Value	Standard error	t-value	Sig (99%)	Value	Standard error	t-value	Sig (99%)
1997	-3.623	1.234	-2.937	YES	34.692	5.597	6.198	YES	0.045	0.086	0.520	NO	-0.08	0.088	-0.86	NO
1998	-6.084	1.344	-4.528	YES	48.803	6.591	7.405	YES	0.204	0.095	2.159	YES (*)	0.06	0.116	0.48	NO
1999	-4.276	1.130	-3.783	YES	46.242	7.112	6.502	YES	0.078	0.077	1.017	NO	-0.01	0.101	-0.08	NO
2000	-4.868	1.331	-3.658	YES	47.509	7.296	6.511	YES	0.087	0.086	1.001	NO	0.06	0.126	0.51	NO
2001	-5.244	1.398	-3.750	YES	54.197	5.935	9.132	YES	0.134	0.073	1.849	YES (**)	-0.04	0.073	-0.59	NO
2002	-5.972	1.148	-5.201	YES	52.924	7.011	7.549	YES	0.173	0.066	2.632	YES	-0.07	0.088	-0.78	NO
2003	-4.481	1.366	-3.281	YES	50.065	7.947	6.300	YES	0.084	0.075	1.122	NO	0.00	0.094	-0.03	NO
2004	-5.179	1.202	-4.309	YES	48.975	5.974	8.198	YES	0.072	0.061	1.179	NO	0.08	0.060	1.34	NO
2005	-3.704	0.856	-4.327	YES	38.799	12.754	3.042		-0.07	0.285	-0.26	NO	-0.42	0.410	-1.01	NO

(*) Significant at the 95% significance level. (**) Significant at the 90% significance level. Source: own elaboration.

[3] This aspect could be a problem with small samples like in this case.

[4] The data are coherent with Schlosser and Blatner (1992). These authors found an average of 2.2 harvesters per car in Oregon National Parks.

the 6.05€ per adult person in 2005 to 14.19€ in 2001, where the average of the period reaches a value of 10.49€.

Finally, the results of the ordinary least squares estimation of the explanations factors of the Marshallian consumer surplus model, described by equation number 7, are presented in Table 3.

In terms of goodness-of-fit statistics for all tested specifications of the model, the exponential model offered the best adjustment with a value of the adjusted R^2 of 0.538. The F ratio test indicates that the results are significant at the 10% level. In terms of estimated coefficients, only fit production in kilogrammes per hectare of *Boletus edulis* was significant (5% level) and positive and, therefore, consistent with the expected. Other variables, like retarded fit production and cost of petrol was non-significant. These variables therefore do not influence the harvesters' well-being in any significant way. In this case, it is only important if the visitor finds edible wild mushrooms. In addition, a well-informed harvester only travels if a certain quantity of this forest production is expected to be collected, and their well-being will increase in an exponential form with their harvest. Therefore, recreational harvesters visit more to look for edible wild mushrooms in propitious season because the fundamental variable to travel is find edible wild mushrooms. That is to say, there is a negative relationship between the wellbeing of recreational harvesters and the value of the edible wild mushrooms they picked compared to their price in local markets[5], since in high season prices tend to drop. This behaviour differs from commercial harvesters who prefer to collect at high prices although the quantity would be reduced, increasing their income wherever possible[6].

Conclusions and discussion

The knowledge of the demand function is fundamental for the management of this resource. Its estimation allows us to calculate the maximum willingness to pay, in the form of Marshallian consumer surplus, through a hypothetical regulation of edible wild mushrooms picking, the access permits that increase travel costs. In the case of '*Pinar Grande'* the average of the period under study reaches a value of 21.41€ per car (10.49€ per adult person) and varies between 12.59€ per car (6.05€ per person) in 1995 and 28.73€ per car (14.91€ per person) in 2001. These values depend on the seasonal variations in production of edible wild mushrooms in this zone. In particular, the season, considered in terms of edible wild mushroom availability in the forest, accounts for approximately 54% of the Marshallian consumer surplus of recreational harvesters.

Several authors find similar values applying this methodology to other recreational activities in natural spaces in Spain during the study period. For example, using ZTCM, Campos and Riera (1996) estimate the MCS in 8.41€ per visitor to Monfragüe Natural Park and Riera y Farreras (2004) in 37.06€ per car in tourism in the Basque Country[7]. Using ITCM, Pérez y Pérez et al (1996), Saz (1996) and García and Colina (2004) calculate these values in 14.21€, 15.24€ and 15.55€ per visitor respectively to several natural parks in Spain (Posets Maladeta, L´Álbuera and Somiedo)

Table 3. Ordinary least squares estimates for Marshallian consumer surplus of recreational harvesting of edible wild mushrooms in *'Pinar Grande'* (Soria, Spain): summary model and parameters

Summary model	Value	Parameters	Value	Standard error	t-value	Sig (95%)
R	0.843	α'	3.207	0.633	5.064	YES
R2	0.711	β_1'	0.009	0.003	2.643	YES
Adjusted R2	0.538	β_2'	0.001	0.003	0.238	NO
F	4.113	β_3'	-0.362	0.764	-0.827	NO
Sig (95%)	YES (*)					
Durbin-Watson	2.748					

(*) Significant at the 90% significance level. Source: own elaboration.

[5] In favourable seasons there is a negative relationship between the production of edible wild mushrooms and their price, in the sense expressed by the economic theory.

[6] Its depends on the price-elasticity of edible wild mushrooms demand in the markets

[7] These authors use out-of-pocket cost like independent variable.

The comparison is paradoxical with the results of edible wild mushrooms TCM studies in Spain. For example, Mártinez de Aragón (2005), using ITCM estimates in 38.22€ for each person who harvests in Solsones area (Catalonia). The explanation could be the use of out-of-pocket cost as an independent variable instead petrol cost as in our case. Martínez Peña (2003) finds bigger differences in the same study area (Pinar Grande) with 188€ per car. The source of divergence could be due to the use of full-car-running cost, the absence of local harvesters in the sample or econometrics aspects during the process of estimation of demand function.

We can also compare the range of estimated Marshallian consumer surplus of recreational harvesters (6.05-14.91 euros) with the daily recreational licence cost in regulated areas (5 euros). This demonstrates that there is an important difference which could be incorporated into tax management and the regulation of the resource via harvest fees. Another matter is the social response to an increase in the cost of licences, which would need investigating beforehand.

In conclusion, if the consumer surplus depends on edible wild mushroom production, so too would the hypothetical harvest fee. The found exponential relation could serve as an aid to managers of the resource when deciding upon the rate. Thus, for low edible wild mushrooms productions in the forest, lower consumer surpluses for harvesters and vice versa. For low edible wild mushroom production, the fees do not have to be very high but could grow substantially according to improvements in the mushroom season.

Acknowledgements

The authors are indebted to Fernando Diaz of the applied mathematic department of University of Valladolid (Spain) for his support with the mathematical resolution of the integration process and Andrés Vadillo, Boni Soria and Aurora Cabrejas for their professionalism in the data collection process.

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Appendix

$$MCS = \int_{atc}^{mtc} e^{\hat{\alpha}+\frac{\hat{\beta}_1}{TC}} dTC = \int_{atc}^{mtc} e^{\hat{\alpha}} e^{\frac{\hat{\beta}_1}{TC}} dTC = e^{\hat{\alpha}} \int_{atc}^{mtc} e^{\frac{\hat{\beta}_1}{TC}} dTC$$

$$Variablechange \to \frac{1}{TC} = t \Rightarrow dTC = -\frac{-dt}{t^2}, t_1 = \frac{1}{mtc}, t_0 = \frac{1}{atc} \Rightarrow$$

$$MCS = e^{\hat{\alpha}} \int_{\frac{1}{atc}}^{\frac{1}{mtc}} e^{\hat{\beta}_1 t} (-dt/t^2) = -e^{\hat{\alpha}} \int_{\frac{1}{atc}}^{\frac{1}{mtc}} \frac{e^{\hat{\beta}_1 t}}{t^2} dt = e^{\hat{\alpha}} \int_{\frac{1}{mtc}}^{\frac{1}{atc}} \frac{e^{\hat{\beta}_1 t}}{t^2} dt = (I)$$

$$f(t) = e^{\hat{\beta}_1 t}; f'(t) = \hat{\beta}_1 e^{\hat{\beta}_1 t}; f''(t) = \hat{\beta}_1^2 e^{\hat{\beta}_1 t}; f'''(t) = \hat{\beta}_1^3 e^{\hat{\beta}_1 t}; \ldots; f^{(n)}(t) = \hat{\beta}_1^n e^{\hat{\beta}_1 t}$$

$$f(0) = 1; f'(0) = \hat{\beta}_1; f''(0) = \hat{\beta}_1^2; f'''(0) = \hat{\beta}_1^2; \ldots; f^{(n)}(0) = \hat{\beta}_1^n$$

$$f(t) = e^{\hat{\beta}_1 t} = 1 + \frac{\hat{\beta}_1}{1!} * t + \frac{\hat{\beta}_1^2}{2!} * t^2 + \ldots = \sum_{n=0}^{\infty} \frac{\hat{\beta}_1^n}{n!} * t^n \, (folowingMcLaurin)$$

So we can integrate (l) in the following way:

$$g(t) = \frac{e^{\hat{\beta}_1 t}}{t^2} = \sum_{n=0}^{\infty} \frac{\hat{\beta}_1^n}{n!} * t^{n-2}$$

If G(t) is the primitive of g(t) then,

$$G(t) = -\frac{1}{t} + \hat{\beta}_1 \ln t + \frac{\hat{\beta}_1^2}{2!} * t + \frac{\hat{\beta}_1^3}{3!} * \frac{t^2}{2} + \ldots = -\frac{1}{t} + \hat{\beta}_1 \ln t + \sum_{n=0}^{\infty} \frac{\hat{\beta}_1^{n+2}}{(n+2)!} * \frac{t^{n+1}}{n+1}$$

So, following Barrow:

$$(I) = e^{\hat{\alpha}} \int_{\frac{1}{mtc}}^{\frac{1}{atc}} g(t) dt = e^{\hat{\alpha}} \left[G(t) \right]_{\frac{1}{mtc}}^{\frac{1}{atc}} = e^{\hat{\alpha}} \left[G\left(\frac{1}{atc}\right) - G\left(\frac{1}{mtc}\right) \right] =$$

$$e^{\hat{\alpha}} \left[\begin{array}{l} \left(-atc + \hat{\beta}_1 \ln \frac{1}{atc} + \left(\frac{\hat{\beta}_1^2}{2!}\right) * \left(\frac{1}{atc}\right) + \left(\frac{\hat{\beta}_1^3}{3!*2}\right) * \left(\frac{1}{atc^2}\right) + \ldots \right) - \\ \left(-mtc \right) + \hat{\beta}_1 \ln \frac{1}{mtc} + \left(\frac{\hat{\beta}_1^2}{2!}\right) * \left(\frac{1}{mtc}\right) + \left(\frac{\hat{\beta}_1^3}{3!*2}\right) * \left(\frac{1}{mtc^2}\right) + \ldots \end{array} \right] =$$

$$e^{\hat{\alpha}} \left\{ (mtc - atc) + \hat{\beta}_1 \ln \frac{mtc}{atc} + \left(\frac{\hat{\beta}_1^2}{2!}\right) * \left[\left(\frac{1}{atc}\right) - \left(\frac{1}{mtc}\right) \right] + \left(\frac{\hat{\beta}_1^3}{3!*2}\right) * \left[\left(\frac{1}{atc^2}\right) - \left(\frac{1}{mtc^2}\right) \right] + \ldots \right\}$$

Then

$$MCS = e^{\hat{\alpha}} \left\{ (mtc - atc) + \hat{\beta}_1 \ln \frac{mtc}{atc} + \sum_{n=0}^{\infty} \left[\frac{\hat{\beta}_1^{n+2}}{(n+2)!*(n+1)} * \left(\frac{1}{atc^{n+1}} - \frac{1}{mtc^{n+1}} \right) \right] \right\}$$