2015
12

Working Paper
INSTITUTO DE POLÍTICAS Y BIENES PÚBLICOS (IPP)

SIMULATED EXCHANGE VALUES AND ECOSYSTEM ACCOUNTING

Alejandro Caparrós
José L. Oviedo
Alejandro Álvarez
&
Pablo Campos

INSTITUTO DE POLÍTICAS Y BIENES PÚBICOS – CSIC

Instituto de Políticas y Bienes Públicos
Consejo Superior de Investigaciones Científicas
C/ Albasanz, 26-28
28037 Madrid (España)

Tel: +34 91 6022300
Fax: +34 91 3045710

http://www.ipp.csic.es

How to quote or cite this document:

Caparrós, A., Oviedo, J.L., Álvarez, A., & Campos, P. (2015). Simulated Exchange Values and Ecosystem Accounting. Instituto de Políticas y Bienes Públicas (IPP) CSIC, Working Paper. 2015-12.

Available at: digital.csic.es

Simulated Exchange Values and Ecosystem Accounting

Alejandro Caparrós*, Jose L. Oviedo,
Alejandro Álvarez and Pablo Campos

Institute for Public Goods and Policies (IPP),
Consejo Superior de Investigaciones Científicas (CSIC), Madrid (Spain).
*Corresponding author's e-mail: alejandro.caparros@csic.es

Abstract

This paper discusses the Simulated Exchange Value method, a practical method to estimate values for goods and services currently outside of the market in a consistent manner to market based figures considered in national accounts. The method proposes to simulate, in a partial equilibrium context, the price that would occur if a good or service outside of the market, such as free access recreation in forests, were internalized. The method takes into account the demand, estimated using non-market valuation techniques, the supply and the market structure. The discussion covers the case of a linear demand and the case where the demand is estimated using discrete choice methods. The paper applies the method to free access recreation in the forests of Andalusia, in the South of Spain, and compares the results to those obtained using Hicksian variations.

Key words: Green accounting, recreation, non-market goods and services, Andalusia, AAS, SEEA, SNA, forests.

1 Introduction

Ecosystems contribute to provide many goods and services that are relevant to society and there is an increasing interest in scientific and political arenas for extending the System of National Accounts (SNA) to account for this contribution (Heal and Kriström 2005; Stiglitz et al. 2009). The United Nations Statistical Office, in cooperation with the European Commission, the World Bank and the OECD have recently presented the new version of the System of Environmental and Economic Accounts – Central Framework (SEEA) (UN et al., 2014a) and the SEEA Experimental Ecosystem Accounting framework (UN et al., 2014b). The World Bank has also launched the ambitious WAVES program to start pilot applications of ecosystem accounting in a handful of developing countries (Atkinson, 2010). Relevant precedents can be found in the Millennium Ecosystems Assessment and the TEEB project (Alcamo et al., 2003; TEEB, 2010). At a national scale, relevant initiatives are the SEAA accounts in Australia (Obst and Vardon, 2014) and the project RECAMAN in the South of Spain (Campos and Caparrós, 2016). Within a cost-benefit framework[1], recent large scale applications can be found in the UK National Ecosystem Assessment (UK NEA) (Bateman et al., 2013).

Valuation of non-market goods and services produced by ecosystems has traditionally focused on the demand side, using non-market valuation techniques (Bateman et al., 2002; Bateman, et al., 2013). The standard procedure consists in selecting a random sample of the general population to be investigated and to confront respondents with a questionnaire where they have to state their willingness to pay to support, or not, a program involving the provision of an environmental service. Data are then analyzed using the basic multinomial logit model and its recent developments (mixed logit and generalized multinomial logit) that allow estimating the probability that a member of the sample (and indirectly the population) would be willing to pay a given amount of money. These probabilities are interpreted as a demand function allowing the estimation of the different Hicksian variations (which are equivalent to the consumer surplus if the income effect is small).

Hicksian variation estimates are relevant in cost-benefit analysis but for ecosystem accounting one needs to distinguish the part that could, in fact, be

[1] Both approaches have different aims and are complementary (Edens and Hein, 2013; Remme et al., 2015). In the accounting framework, the goal is to structure data on current final consumption and own gross net investment. Cost-benefit analyses focus on welfare changes associated to different land uses.

internalized in terms of prices times quantities. Therefore, Cairns (2003) proposed focusing exclusively on the part that can be internalized, as this is the only part that is consistent with current estimates in the conventional System of National Accounts (SNA). Independently, and to translate this theoretical result into applications, Caparrós et al. (2003) proposed the Simulated Exchange Value (SEV) method. In a nutshell, the method consists in using demand functions estimated with the non-market valuation methods described above to simulate the whole market (demand, supply and competitive environment) in order to obtain the market value that one could get from a given ecosystems service *if* it were internalized. An analysis of the relationship between the SEV and the theoretical literature can be found in Caparrós (2010) or in Caparrós and Ruiz-Gauna (2015).

The SNA and the SEEA also oppose the use of consumer surplus, proposing the use of exchange values instead, as long as these are observable (UN et al., 2014a). Even if a good is recollected free and without paying a price (e.g. mushrooms), the SEEA proposes to use the price of that good in other markets. Applications can be found in Hultkrantz (1992), Kriström and Skånberg (2001), Campos and Caparrós (2006) or Ovando et al. (2016). The SEV goes a step further and proposes to simulate exchange values for non-market ecosystem services for which no similar market exists. This implies to simulate, in a partial equilibrium context, the price that would occur if a good or service outside of the market, such as free access recreation, were internalized.

The plan of the rest of the article is as follows. Section 2 discusses the SEV under different assumptions. Section 3 illustrates the use of this method with one particular application to free access recreation and, finally, section 4 concludes.

2 The Simulated Exchange Value method

As stated above, the central normative national accounts framework (European Commission et al., 2009) proposes the use of prices from similar markets as a first alternative when no direct market prices for environmental services are observable. Hultkrantz (1992) and Matero and Saastamoinen (2007) apply this method to non-timber products partially traded in markets in Sweden and Finland, respectively. However, there are other goods and services provided by ecosystems where no prices from similar markets exist. Examples are free access recreation to forests, landscape values or biodiversity. In those cases, the temptation is to use the consumer surplus or any other Hicksian surplus measurement obtained with non-market valuation techniques. However, these values are not consistent with market values and national accounting, as repeatedly highlighted in official documents and in the scientific literature. Among the first, in United Nations et al. (2003: 407) we could read that "[…] contingent valuation […] gives an average willingness to pay figure which includes an element of consumer surplus […]. This poses a problem […], since the national accounts exclude consumer surplus." More recently, in Obst et al. (2013: 420), we can read that "[…] "The [SEEA-EEA] approach aims to record the "output" generated by ecosystems, given current uses of ecosystem capital; thus, monetary values represent exchange values consistent with the principles of national accounting".

Concerning the scientific debate, Weitzman (1976) started the literature on green national accounting by deriving the important result that by linearizing the Hamiltonian in a Ramsey-style model of the whole economy, one obtains the definition of the Net National Product (NNP), the most relevant indicator estimated in the System of National Accounts. This result was extended to cover exhaustible resources, renewable resources and the negative effects of pollution in Solow (1986), Hartwick (1990) or Mäler (1991), among others. The specific case of forests and terrestrial ecosystems was covered in Vincent (1999) and Cairns (2001, 2003). As shown, for example, in Cairns (2001) by evaluating consumption and amenities at the margin and by linearizing the 'affine Hamiltonian' we purge it from the consumers' surplus. Purging the non-linearities permits aggregating results from small economic units at the economy's shadow prices, as is done in traditional NNP using market prices as proxies for shadow prices (in other words, NNP correspond to a linear, and hence additive, index of intertemporal welfare (Cairns, 2001)). Thus, as pointed out by Cairns (2001) "the part of consumers' surplus which is attributable to amenities, should not be part of green NNP, just as the part which is attributable to marketed goods is not a part of traditional NNP" (arguments in the same direction can be found in Ahmad et al. (1989), Caparrós et al. (2003), Cairns (2003, 2008) and Caparrós and Ruiz-Gauna (2015)).

Thus, the goal is to estimate the price that would realistically be implemented *if* ecosystem services were internalized. To fix ideas, we use free access recreation in terrestrial ecosystems (such as forests) as an example but other amenities could be treated in a similar way. We first analyze the case of a linear demand function due to its simplicity, and then extend the analysis to cover the case where the demand is estimated using discrete choice methods, either with closed functional forms or through simulations. In both cases, we assume that the manufactured total costs (essentially cleaning and warden costs) faced by the forest owner (which may or not be the government) to provide the free access recreational service are given by $C(q)=c_1+c_2q+((c_3)/2)q^2$, where q are the number of visitors.

2.1 Linear demand function

Assume that the site-specific demand for recreational access to the forest i (we drop the subindex i for simplicity), which is currently under free access, is given by $p=P(q)=\alpha_1-\alpha_2q$, where p is price and P the demand function

Perfect competition

The SEV method proposes to simulate what the non-market output would be *if* recreation were internalized. If the market were under perfect competition the equilibrium would be given by the intersection of $P(q)$ and $C'(q)$. Hence

$$q^P=\frac{\alpha_1-c_2}{c_3+\alpha_2}; \qquad p^P=\alpha_1+\frac{\alpha_2(c_2-\alpha_1)}{c_3+\alpha_2},$$

where P in superscript stands for perfect competition. Thus, the non-market output to be included in the ecosystem accounts would be:

$$p^Pq^P=\frac{(c_2\alpha_2+c_3\alpha_1)(\alpha_1-c_2)}{(c_3+\alpha_2)^2}$$

From a national accounting perspective one of the problems arising if costs are variable is that the new simulated market would imply less costs than those actually incurred by the agents (government and private agents). This problem does not arise when costs are assumed to be fixed, an assumption that is reasonable in many instances, either because marginal costs are negligible or because there is not enough information to construct a meaningful marginal cost curve. We therefore consider in all cases below the implications of this assumption. For the case analyzed in this section we would have:

$$q^P=\frac{\alpha_1}{\alpha_2}=Q; \;\; p^P=0; \quad p^Pq^P=0,$$

where Q stands for the number of visitors for a price equal to zero (the current number of visitors if the area is under free access). That is, the equilibrium price would be zero (see Mäler et al. (2009) for a discussion of a similar result).

Monopolistic competition

In the previous sub-section we analyzed the outcome under perfect competition. This implies to assume that there are a very large number of terrestrial ecosystems (forests) with recreational values and that all have the same characteristics. In addition, the assumption is that new entries of recreational sites are possible without limitations. Assume now that there is a given number of recreational areas and that new entries are (in principle) possible but need a considerable amount of time. Thus, in the short run, the number of recreational areas is fixed and each area would have a site-specific demand function. This corresponds to a market under monopolistic competition.

In the short run the equilibrium is given by the intersection between the site-specific marginal revenue function, $R'(q)=P(q)+P'(q)q$, and the site-specific marginal cost function, i.e. where $R'(q)=C'(q)$. This yields:

$$q^M = \frac{\alpha_1 - c_2}{c_3 + 2\alpha_2}; \qquad p^M = \frac{c_2\alpha_2 + c_3\alpha_1 + \alpha_1\alpha_2}{c_3 + 2\alpha_2},$$

where M in superscript stands for monopolistic competition.

Thus, in the short-run the non-market output *if* the market would be internalized under monopolistic competition would be:

$$p^M q^M = \frac{(\alpha_1 - c_1)(c_2\alpha_2 + c_3\alpha_1 + \alpha_1\alpha_2)}{(c_3 + 2\alpha_2)^2}$$

In the long run, monopolistic competition assumes that new entries are possible and that this will drive benefits to zero. The standard model assumes that every new entry reduces the demand for all. However, in the case of terrestrial ecosystems new entries are not easy even in the long-run. In addition, we are not working with the total demand of the sector, but already with the site-specific demand, and the production account in SNA is not about the long-run. Thus, it is more reasonable to use the vales estimated for the short-run.

Before moving on, note that if there are no marginal costs we would have:

$$q^M = \frac{\alpha_1}{2\alpha_2} = \frac{Q}{2}, \qquad p^M = \frac{\alpha_1}{2}$$

and p^M would be the median. This provides a rationale for using the median times 50% of the population as an indicator of environmental output, a strategy that simplifies the computational requirements and that was used in Caparrós et al. (2003).

If the owner of the terrestrial ecosystem (forest) has market power, as assumed in monopolistic competition in the short run, he/she could in theory charge each visitor a different price and internalize all the Hicksian variation of the site-specific demand function (or all the consumer surplus if the income effect is small). As pointed out by Caparrós et al. (2003) this is probably too strong an assumption if the objective is to simulate a real market. Nevertheless, although we will not analyze it here due to the arbitrarity that it would introduce, one could consider a situation where the owner can set a reduced number of different prices.

2.2 Discrete choice with closed functional forms

Most non-market valuation studies do not estimate linear demand functions. They typically use discrete choice experiments to estimate various types of logit functions. If the discrete choice has only one alternative the method is also known as contingent valuation. In this section we assume that the analysis is done using a standard logit and hence that a closed form solution is available (Train, 2009).

Let us assume that there is a non-market valuation study available for each recreational area. To simplify, let us further assume that all are contingent valuation studies and that visitors were faced only with two alternatives: visiting the area (i=1), at a given price, or staying at home (i=0). Utility of visiting the area is then given by:

$$U_{ni}^L = \beta' x_{ni} + \varepsilon_{ni} = \hat{\beta}' \hat{x}_{ni} + \beta_p p_{ni} + \varepsilon_{ni}, \qquad (1)$$

where x is a matrix that includes all the explanatory variables and β is a vector that includes all the associated coefficients (as we are going to focus on the price, we distinguish, within x an β, the price, p, and the coefficient associated with the price, β_p, reserving the notation $\hat{x}$ and $\hat{\beta}$ for the remaining explanatory variables, i.e, $x = \hat{x} \cup p$ and $\beta = \hat{\beta} \cup \beta_p$). The L in superscript stands for logit.

What the non-market valuation study ultimately estimates is the probability that an average visitor accepts to pay a given amount of money. For the standard logit model the probability that the individual *n* chooses the alternative *i* is (Train, 2009):

$$\Pr_{ni} = \frac{e^{\beta' x_{ni}}}{\sum_j e^{\beta' x_{ni}}}$$

Assuming that the number of visitors at a zero price (initial situation) is known for the particular recreational area considered ($q(0)=Q$), that the price is the same for all visitors, i.e. that $p_{ni}=p_1=p$, and normalizing the parameter values in β such that the utility of not visiting the area is zero, the inverse demand function, $q(p)$, for one particular recreational area can be written as (setting $\hat{x}_{ni}=\overline{x}$, i.e. assuming that the model is well specified and that the sample average represents well the population):

$$q(p) = Q\Pr_i = Q\frac{e^{\widehat{\beta}'\overline{x}+\beta_p p}}{e^{\widehat{\beta}'\overline{x}+\beta_p p}+1}, \quad \text{or} \quad p = P(q) = \frac{\ln(q/(Q-q))}{\beta_p} - \frac{\widehat{\beta}'}{\beta_p}\overline{x}.$$

The perfect competition quantity and price in equilibrium are now implicitly given by the intersection of $P(q)$ and $C'(q)$:

$$\frac{1}{\beta_p}\left(\ln\left(\frac{q}{Q-q}\right) - \widehat{\beta}'\overline{x}\right) = c_2 + c_3 q \quad \Rightarrow \quad q^{PL}, p^{PL} \tag{2}$$

and the short-run monopolistic competition quantity and price are implicitly given by $R'(q)=C'(q)$, or:

$$\frac{1}{\beta_p}\left(\ln\left(\frac{q}{Q-q}\right) - \widehat{\beta}'\overline{x} + \frac{Q}{Q-q}\right) = c_2 + c_3 q \quad \Rightarrow \quad q^{ML}, p^{ML}. \tag{3}$$

The assumption of no marginal costs does not simplify the equation shown for monopolisitic competition, although for perfect completion equation (3) simplifies to:

$$q^{PL} = \frac{e^{\widehat{\beta}'\overline{x}}Q}{1+e^{\widehat{\beta}'\overline{x}}},$$

and p^{PL} is found by substituting q^{PL} in eq. (2).

If the utility function were defined using the log of the price (a strategy frequently used in applications to account for the fact that the demand is not defined for negative values) we would have:

$$U_{ni}^{LL} = \hat{\beta}'\hat{x}_{ni} + \beta_p \ln\left(p_{ni}\right) + \varepsilon_{ni}, \tag{4}$$

where LL in superscript stands for log-logit. For perfect competition we would have:

$$e^{\frac{1}{\beta_p}\left(\ln\left(\frac{q}{Q-q}\right)-\hat{\beta}'\bar{x}\right)} = c_2 + c_3 q \quad \Rightarrow \quad q^{PLL}, p^{PLL}.$$

and for monopolistic competition in the short run:

$$\left(1+\frac{Q}{\beta_p(Q-q)}\right)e^{\frac{1}{\beta_p}\left(\ln\left(\frac{q}{Q-q}\right)-\hat{\beta}'\bar{x}\right)} = c_2 + c_3 q \quad \Rightarrow \quad q^{MLL}, p^{MLL}. \tag{5}$$

The assumption of no marginal costs allows now to simplify equation (5), so that the equilibrium number of visits under monopolistic competition is given by:

$$q^{MLL} = Q - \frac{Q}{\beta_p},$$

and p^{MLL} is found by substituting q^{MLL} in equation (5).

2.3 Discrete choice with simulation

Instead of using the standard logit we now assume that the researcher has estimated a mixed logit model. The utility is now assumed to be given by $U_{ni}^{R} = \beta_n' x_{ni} + \varepsilon_{ni} = \hat{\beta}_n' \hat{x}_{ni} + \beta_{pn} p_{ni} + \varepsilon_{ni}$, where β_n are distributed with density $f(\beta|\theta)$, θ refers collectively to the parameters of this distribution (this distribution is frequently assumed to be a normal). The probability that we are interested in is (Train, 2009):

$$\Pr_{ni} = \int L_{ni}(\beta) f(\beta|\theta) d\beta,$$

where $\mathrm{L}_{ni}(\beta) = \frac{e^{\beta' x_{ni}}}{\sum_{j=1}^{J} e^{\beta' x_{ni}}}$.

As this formula has no closed form solution, the standard approach is to approximate the probabilities through simulation. This process implies to draw repeated values of β from $f(\beta|\theta)$ and averaging over the results obtained for each value of θ to obtain the simulated probability

$$\breve{\Pr}_{ni}(\theta) = \frac{1}{m}\sum_{r=1}^{m} L_{ni}(\beta^{r}),$$

where m is the number of draws. Then, the researcher estimates the value θ^* that maximizes the simulated log likelihood function. This allows to determine $\breve{P}_{ni}(\theta^*)$.

Drawing again a large number of random draws one can numerically find a non-parametric price function. To do this, set $\hat{x}_{ni} = \bar{x}$, and simulate $q(p) = Q\breve{P}_{ni}(p|\theta^*)$ for a large number of values within $p = \left[\underline{p}, \bar{p}\right]$, where $\underline{p}$ is a minimum value for the price (e.g. zero) and $\bar{p}$ is the maximum value considered, drawing for the simulation for each price considered a large number of draws from $f(\beta\|\theta^*)$ and averaging. Then, define the inverse function $f(q) = q^{-1}(p)$ and finally define the function $g(q) = \frac{f(p+h) - f(p)}{h}$ where h is a small number that makes $g(q)$ almost a continuous function (although it does not necessarily tend to zero). The equilibrium is given implicitly by $f(q) \approx c_2 + c_3 q$ for perfect competition and by $f(q) + g(q)q \approx c_2 + c_3 q$ for monopolistic competition. Finally, note that in both cases, if marginal revenues are zero, the RHS is zero, and that similar equations are valid for the log-logit case.

3 Application to free access public recreation in Andalusian forestlands

3.1 Materials and methods

Andalusia is a region of about nine million hectares located in the South of Spain. It is a very diverse region, ranging from sea level up to 3,400 meters and from the rainiest point in the Iberian Peninsula to the desert of Almeria. Mediterranean forestlands, one of the biodiversity hotspots of the world, cover over 52% of Andalusia. These are complex ecosystems where forests and grasslands have been traditionally managed jointly to obtain cork, timber, firewood, nuts, hunting and grazing resources. Andalusian forestlands receive a large number of visitors, as our survey has shown, and the importance of public recreation in this area has been growing over the last decades. As there are important costs involved in providing these recreational services, an economic assessment of the income generated has empirical relevance.

Access to protected areas is generally free of charge in Andalusia, at least in public lands, although visitors have no legal right to access all public land and there are exceptions where access is limited for environmental reasons (in Doñana National Park only guided visits are allowed and visitors need to pay for this service). In private land, owners can prohibit access and visitors have only the right to use public roads. Therefore, a scenario where visitors would need to pay to access recreational areas is credible.

The site-specific demand functions for public recreation in the different terrestrial ecosystems in Andalusia are estimated using two surveys done in 2010. In the first survey, questionnaires were made through face-to-face interviews to a sample of 4,030 free access visitors (≥ 18 years old) in 9 different sites of Andalusian *montes*[2]. The questionnaires included a double-bounded CV question that asked visitors if they would be willing to pay a specific bid for making the same recreational visit that they were doing, on that same day and on that particular *monte* site. This CV scenario used two payment vehicles: the payment of an entrance fee and the payment of additional trip-expenditures as a consequence of an increase in fuel price (the wording can be found in Appendix A). Around half the sample faced the entrance-fee and the other half the increase in trip-expenditures as payment vehicles (see Campos et al. (2007) for a discussion about the implications of both wordings).

For simplicity, we present only results for the single-bounded question, as those obtained with the double-bounded question were similar. We estimate a logit model based on the utility function in equation (1) and a log-logit model based on equation (4) above. The models include as explanatory variables categories for the 9 *montes* sites where questionnaires were made and a dummy variable for the payment-vehicle. In addition, the models include the following explanatory variables: total expenses during the visit, respondent's age, whether the respondent belongs to a nature conservation association and whether the respondent would come back to the site. The models also include the bid in the case of the logit function and the log of the bid in the case of the log-logit function. The selected models are presented in Table 1 and were preferred over other models tested. The criteria to choose these models follow a combination of goodness-of-fit measures (*McFadden's pseudo-*r^2 and *Akaike information criterion* (AIC)) and looking for as many significant explanatory variables as possible.

---

[2] The term "montes" includes forests and rough grasslands The 9 montes directly analyzed were *Alcornocales*, *Cazorla*, *Aracena*, *Cabo de Gata-Níjar*, *Sierra Nevada*, *Sierra de Grazalema-Las Nieves*, *Pinares de Doñana*, *Sierra María-Los Vélez* and *Andujar-Hornachuelos-Despeñaperros*. The latter include three *montes* sites that were relatively close and with similar vegetations, and then were grouped together in the valuation exercise.

Random parameter logit estimations for these CV models were also tested but they did not improve the models' fit or the significance of explanatory variables. Much of the heterogeneity in the answers is probably captured by the explanatory variables associated to respondents' characteristics[3].

In the second survey, face-to-face interviews were done to a sample of 3,214 adults (≥ 18 years old) from Andalusian households and 836 adults from households from the rest of Spain. These questionnaires included a set of questions that asked respondents the number of day-visits that they had done to different Andalusia *montes*

Table 1. Logit and log-logit models for the analysis of the single bounded CV question for the valuation of public recreation in 9 montes in Andalusia.

Explanatory variables	Logit model		Log-logit model	
	Coefficient	*p-value*	Coefficient	*p-value*
Intercept	1.1351***	0.0000	2.3325***	0.0000
Bid	-0.2124***	0.0000		
Log of bid			-1.4662***	0.0000
Alcornocales site	-1.0707***	0.0000	-1.0695***	0.0000
Andújar-Despeñaperros-Hornachuelos site	-0.2805*	0.0582	-0.2872*	0.0531
Aracena site	0.3952**	0.0107	0.3912**	0.0118
Cabo de Gata-Níjar site	0.2639*	0.0786	0.2670*	0.0755
Cazorla site	0.3881***	0.0042	0.3758***	0.0056
Sierra de Grazalema-Las Nieves site	0.1876	0.1768	0.1907	0.1702
Sierra María-Los Vélez site	0.2581	0.1506	0.2643	0.1408
Sierra Nevada site	-0.1417	0.2423	-0.1323	0.2760
Payment vehicle (dummy = 1 if increase in trip-expenditures)	1.5471***	0.0000	1.5517***	0.0000
Respondet's age (years)	0.0090**	0.0354	0.0090**	0.0358
Total expenses in the visit	0.0055***	0.0000	0.0055***	0.0000
Dummy = 1 if the respondent belongs to a nature conservation association	0.5262**	0.0401	0.5234**	0.0410
Dummy = 1 if the respondent would come back to the site	-1.7953**	0.0173	-1.8059**	0.0177
McFadden's pseudo-R^2	0.18		0.18	
Akaike Information Criterion	2,327.50		2,317.60	
n*	2,370		2,370	

* For these models, out of the total sample of 4,030 respondents, we have identified 298 no answers to the CV question, 1.057 protest responses and 305 cases with missing values for the explanatory variables. When these cases are removed, the final sample for the models has 2,370 observations.
Asterisks (e.g.,***,**,*) denote significance at the 1%, 5% and 10% level, respectively.

[3] Although random parameter models can be used in the analysis of CV questions, they are more often used for choice experiments where a bundle of attributes define the good and more alternatives are presented with differing attribute levels for the good. In this setting, preference heterogeneity is likely to have more impact in the models' fit and significance of explanatory variables.

in the 12 months previous to the interview. This provides the information needed to estimate the number of visits to different *montes* sites in Andalusia in 2010; that is, the numbers of visits under free access. This survey identified 18 *montes* sites with presence of public recreation in addition to the 9 *montes* where the CV survey to visitors was carried out.

The design of these two surveys implied a series of focus group meetings and a pre-test of 96 questionnaires. The bid vector offered in the double bounded CV question was designed based on the results from an open-ended CV question included in the pre-test questionnaire. We followed the proposal of Alberini (1995) of maintaining the log of the distance between bids constant, as it is a good compromise between efficiency and information about the shape of the WTP distribution needed. The bid values were €3, €6, €9 and €12 in the single bounded question.

We assume that all 27 areas where public recreation was observed would operate under monopolistic competition in the short run, each one facing its own site-specific demand function. For the 9 *montes* investigated directly the demands were derived by using the site-specific dummy variable, and the average in the population of the visitors to that site for the remaining variables. For the remaining 18 sites we used the dummy variable and the averages of the closest site investigated (or the most similar site).

Concerning costs, only costs paid by the government have been taken into account. The government assumes direct (using own production factors) or indirect (through subcontractors) expenditures on activities that affect the supply of private and public products in Andalusian forests. This study focuses on those activities supported by the Regional and Spanish governments that are primarily concerned with the provision of public recreational services to free-access visitors.

The estimation and allocation of outputs and costs associated to government expenditures required a functional classification of these expenses, and additional surveys to public servants and subcontractors to estimate direct and indirect total costs for those non-market public products affected by government expenditures in Andalusia (see Ovando and Campos (2016) for details).

Government expenditures yield ordinary environmental protection and management services, as well as, manufactured (tangible or intangible) assets that are used to provide public non-market services (e.g.: constructions, equipments, cartography, research projects, etc). Government investment in manufactured assets is an own-account production, and following the SNA recommendations the value of outputs produced for own final use is deemed to equal its production cost (European Commission et al., 2009: 110). On the other hand, government expenditures on ordinary activities are distributed into labor, and intermediate and fixed capital consumptions.

3.2 Results

Table 1 shows the results for the two models estimated using the data obtained from the 4,030 open access visitors to the 9 *montes* investigated directly. The two functional forms shown (logit and log-logit) yield similar fits in the regression models and the significance of the explanatory variables are also similar in both functions. For calculating the aggregated results, we use the logit model estimations as they offer a more direct and easier interpretation.

Based on the results of the first model shown in Table 1, the logit model, we estimated site-specific demand functions for each one of the recreational areas considered. As an example, Figure 1 shows the demand function used to estimate the price for free access recreation in Cazorla (one of the areas considered). The equivalent figures for the remaining 8 recreational areas where surveys took place are qualitatively similar.

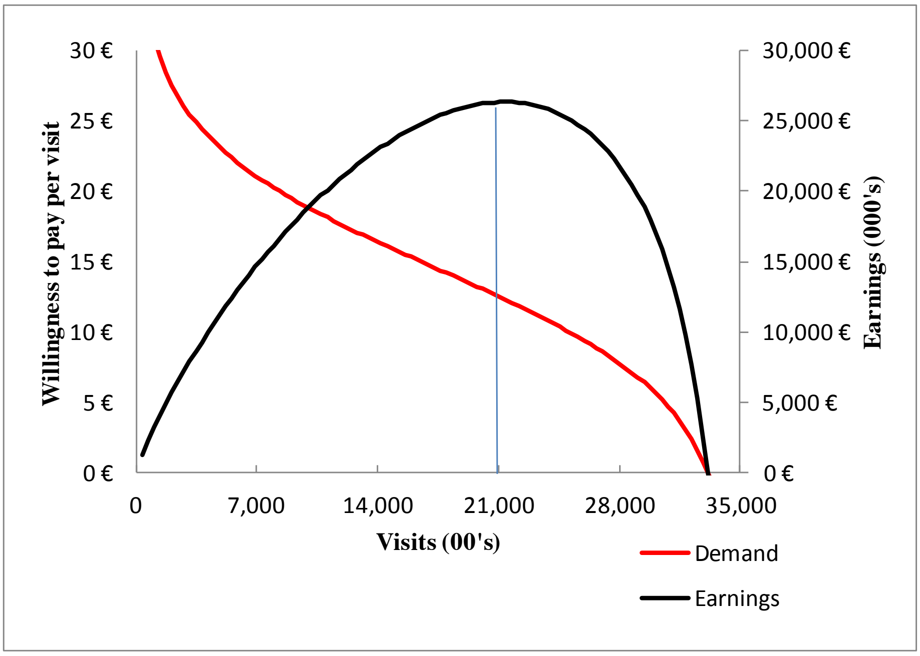

Figure 1. Demand and revenues for recreation in Cazorla

Table 2 present the values for free access recreation using the Hicksian variation and using the SEV estimates, in the latter case using the price that maximizes the revenue under short-term monopolistic competition. The table also shows that the area receives a large number of visitors from Spain according to our estimations (visitors from foreign countries are not included, as our estimations are based on a household survey in Spain). As explained above, we assumed that the cost function has only a fixed component and no marginal costs. Strictly speaking recreational activities have marginal costs, as cleaning costs, for example, depend on the number of visitors. Nevertheless, in the short run these costs are relatively fixed in a situation where cleaning and warding activities are done by the public sector.

As Table 2 shows, the Hicksian (compensating) variation implies larger absolute values and, especially a larger number of visitors, as the SEV only considers the number of visitors that would in fact accept a payment. For the SEV we propose two measures: one based on the shortcut discussed above of using directly the median and one where revenues are maximized. For a linear demand function these two values would coincide by definition, but our results show that for a logistic function both estimations are also similar. For the logit model this is true both for the price per visit and for the aggregated (or per hectare) values. For the log-logit the median and the price that maximizes revenues are not similar, but the relevant values from an accounting perspective are the aggregated ones and they are again relatively similar.

Table 2. Aggregated values using the simulated exchange value (SEV) for free access recreation in Andalucía

Model and estimated values	Per visit (€)	Number of visits	Aggregated values (€)	€/ha
Logit (bid)				
Compensating variation	12.91	26,782,831	345,723,904	78.82
Simulated exchange value (median)	12.91	13,391,416	172,861,952	39.41
Simulated exchange value (maximum)	11.38	15,624,900	177,865,907	40.55
Log-logit (log bid)				
Compensating variation	38.52	26,782,831	1,031,783,830	235.22
Simulated exchange value (median)	15.14	13,391,416	202,712,988	46.21
Simulated exchange value (maximum)	25.31	8,570,506	216,934,005	49.46

Table 2 also shows that, using the SEV, aggregated (or per hectare) values are also relatively robust to a change in the model used, as all the values estimated are roughly between 40 and 50 euros per hectare. On the contrary, the estimations based on the compensating variation are very sensitive, being almost three times higher with the log-logit model than with the logit model.

Table 3 integrates the estimated output for recreation in the production account of the Agroforestry Account System (AAS). A brief description of this accounting system can be found in Appendix B, and details can be found in Caparrós et al. (2003) and Campos and Caparrós (2006). The accounting system allows estimating the Net Operating Margin (NOM), or operating capital income, and the Net Value Added (NVA) of the recreational activity, which were respectively 138,690 and 159,560 thousand euros in 2010 according to our estimations. The value estimated using the SEV described above is recorded in this account as "Public environmental goods and services" and has a total value of 172,866 thousand euros. The difference between this value and the NOM and the NVA is explained by the relatively high costs involved in producing the recreational service.

Table 3. Production account for free access recreation in Andalusia for the year 2010 (in thousands of €)

1. Total output	182,849
1.1 Intermediate output	0
1.2 Final production	182,849
1.2.1 Fixed capital formation	4,983
1.2.2 Public environmental goods and services	177,866
2. Total cost	44,159
2.1. Intermediate consumption	16,021
2.1.1 Raw materials	281
2.1.2 Services	15,740
2.2 Labour	20,870
2.3 Fixed capital consumption	7,268
3. Net Operating Margin	138,690
3.1 Environmental	132,650
3.2 Manufactured	6,040
4. Net Value Added	159,560

For comparison purposes, the NVA recorded in the SNA is about 20,870 thousand euros, i.e. the labor (as all the costs considered are done by the government). However, this NVA value is not recorded in the current SNA in the forestry sector, but in the government sector.

Assuming a standard market return for the manufactured capital involved in the production of free access recreation, one can separate the manufactured NOM and the environmental NOM. The latter corresponds to the resource rent associated to free access recreation. Assuming that this figure remains constant over time, and a 3% social discount rate, the public recreation environmental asset is 4,421,669 thousand euros.

The geographical representations of the net value added for free access recreation under the SEV method can be found in Figure 2. The areas in orange are those where government costs were identified but there were no visits according to our survey to households. The remaining colors show the 27 recreational areas considered. Different values are explained by the significance of the different site-specific dummy variables in the model shown in Table 1, but also by the different amount of visitors that the different areas receive.

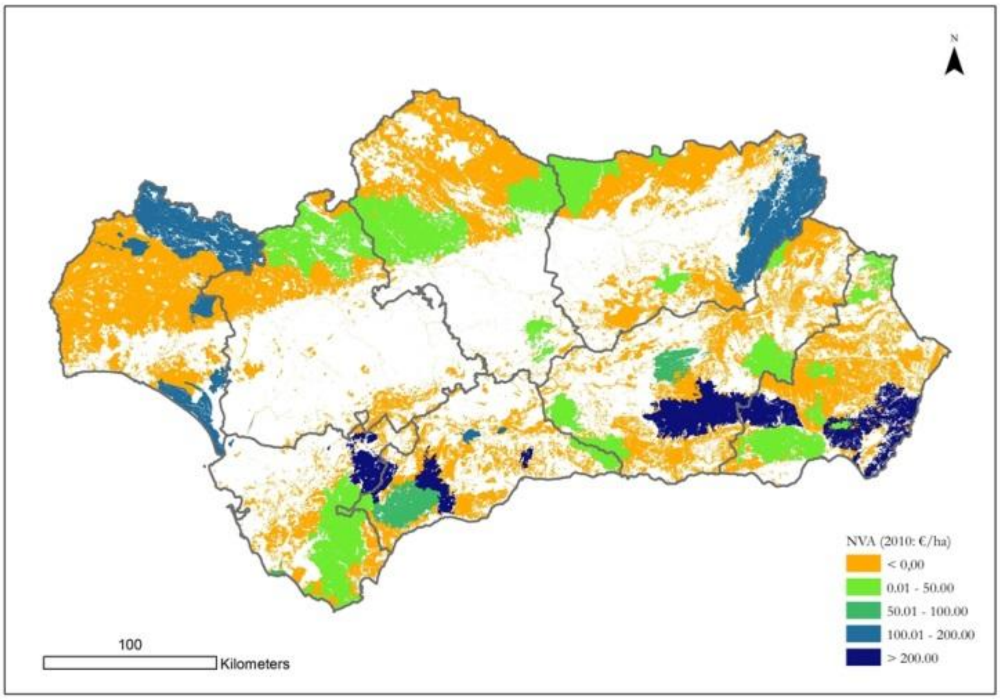

Figure 2. Map of recreational Net Value Added in Andalusia using the SEV

4 Discussion and conclusion

This paper discusses, and applies, the Simulated Exchange Value method, a practical method to estimate values for goods and services currently outside of the market in a consistent manner to market based figures considered in national accounts. As stated above, the use of simulated market values is present in the central national accounts framework, but it is particularly relevant for the different proposals to develop them integrating environmental values, as modeling is unavoidable for this task (Vanoli, 1998). Although the SEV permits greater consistency[4] than the use of exchange values for commercial goods and services and welfare measures for non-commercial goods and services, it nevertheless suffers from the problems associated with all the extension of national accounts based on simulations. Transactions that actually do not exist are simulated, but the budget constraint is not actually affected and relative prices are not modified. Even if the contingent valuation question is well understood and the respondents answer truthfully and taking into account their budget constraint, the accounts of the other sectors should all be modified to incorporate the new distribution of expenses that individuals would make if they needed to pay for recreation. The information required for this task is not easy to obtain, and national accountants are probably unwilling to modify results obtained observing transactions in other sectors based on the results of simulation analyses. However, this problem also applies if goods produced for own consumption are valued using market prices, as the central national accounting framework does. In the same line, and with the same limitations, previous studies (Hultkrantz, 1992) and the new SEEA also propose to value non-timber goods recollected freely, such as mushrooms, at market prices (UN et al., 2014b).

Acknowledging the limitations described, the use of the SEV is considered to be an improvement compared to the alternative of excluding any value for free access recreational services, apart from the labor cost. At least in the context of national accounting, the SEV is also preferable to the option of estimating welfare measures for both commercial and non-commercial goods and services, in a cost-benefit analysis setting, as this diverges from the national accounting framework.

One additional advantage of the SEV (not shared by the Hicksian variations) is that they are robust to changes in assumptions and models. Table 2 has shown that this is true in our application, but the result will hold more generally as the tails of the probability distribution, where different models differ more, have a relatively small

[4] Note that there should be no double-counting with expenses in other sectors, such as the tourism industry, as we are simulating additional payments.

influence on the values obtained applying the SEV (unlike Hicksian variations, which may tend to infinity if the integral does not converge).

A consistent application of the SEV for recreation in different countries would also have the advantage of permitting international comparisons. While some countries, like Spain, do generally not charge visitors to national parks and other publicly owned recreational areas, other countries charge visitors for the access to their national parks. Furthermore, out of those charging prices some apply prices that are designed to extract the largest possible rent from the visitors, as the SEV simulates, while others charge symbolic prices that are essentially determined politically. These three different approaches render data collected on the incomes generated by recreational activities hard to compare. Applying the SEV in all three cases would yield comparable results and, if the estimation is correct, changing from a system where visitors do not pay to one where they do should have no impact on the national accounts.

One of the most obvious extensions of the work presented here is to investigate the role that setting up a price in one recreational area would have on the price of other recreational areas, and vice-versa. Microeconomics provides a number of tools to perform this analysis, but we have decided to leave this issue for future research. Another relevant extension is to apply the SEV to other environmental services. In theory, the method could be applied to any environmental service where a Payment for Ecosystems Services scheme could be implemented, and hence simulated. In fact, in a companion paper we apply the SEV to landscape and threatened biodiversity in Andalusia. Nevertheless, as this alternative application has its own peculiarities and complications we have decided to leave it out of this paper.

Acknowledgements

The authors thank the *Junta de Andalucía* and the *Agencia de Agua y Medio Ambiente de Andalucía* for the support received through the RECAMAN (*Forest income and capital accounting*) project (Contract NET165602). Alejandro Caparrós also benefited from the project ACBPA (ECO2012-35432), funded by MINECO (Spain). Authors are in debt with Paola Ovando for her comments and assistance with the data on government expenditures, and to Bruno Mesa and Cristina Fernandez for technical support.

References

Ahmad Y.J., l Serafy S., Lutz E., 1989. *Environmental Accounting for Sustainable Development*. UNEP and World Bank, Washington.

Alcamo J., et al., 2003. *Ecosystems and human well-being: a framework for assessment*. Island Press, Washington.

Alberini A., 1995. Optimal Designs for Discrete Choice Contingent Valuation Surveys: Single-Bound, Double-Bound, and Bivariate Models. *Journal of Environmental Economics and Management* 28(3): 287–306.

Atkinson G., 2010. *Environmental Valuation and Greening the National Accounts: Challenges and Initial Practical Steps*. Washington D.C.: The World Bank.

Bateman I.J., Carson R.T., Day B., Hanemann M., Hanley N., Hett T., Jones-Lee M., Loomes G., Mourato S., Özdemiroglu E., Pearce D.W., Sugden R., Swanson J., 2002. *Economic valuation with stated preference techniques*. *A manual*. Edward Elgar, Cheltenham, UK.

Bateman I., Harwood A.R., Mace G.M., Watson R.T., Abson D.J., et. al., 2013. Bringing Ecosystem Services into Economic Decision-Making: Land Use in the United Kingdom. *Science* 341, 45–50.

Cairns R.D., 2001. Seeing the trees as a forest: what counts in green accounting. *Ecological Economics* 36: 61–69.

Cairns R.D., 2003. Reconciling the Green Accounts. *Environmental and Resource Economics* 25: 51–63.

Cairns R.D., 2008. Value and Income. *Ecological Economics* 66: 417-424.

Campos P., Caparrós A., 2006. Social and Private Total Hicksian Incomes of Multiple Use Forests in Spain. *Ecological Economics* 57 (4), 545–557.

Campos P., Caparrós A., Oviedo J.L., 2007. Comparing Payment-Vehicle Effects in Contingent Valuation Studies for Recreational Use in two Spanish Protected Forests. *Journal of Leisure Research* 39(1): 60-85.

Campos P., Caparrós A., (editors), 2016 (*forthcoming*). *Valoración de los servicios públicos y la renta social de los sistemas forestales de Andalucía*. Memorias científicas de RECAMAN. Volumen 5. Editorial CSIC, Madrid.

Caparrós, A., 2010. Contabilidad Nacional Verde en el Sector Forestal: de la Teoría a la Práctica. *Cuadernos de la Sociedad Española de Ciencias Forestales* 31: 251-262.

Caparrós A., Campos P., Montero G., 2003. An Operative Framework for Total Hicksian Income Measurement: Application to a Multiple Use Forest. *Environmental and Resources Economics* 26, 173–198.

Caparrós A., Ruiz-Gauna I., 2015. *Green accounting in a multi-sector model with terrestrial ecosystems*. IPP Working paper, Madrid.

European Commission, International Monetary Fund, Organisation for Economic Cooperation and Development, United Nations, World Bank, 2009. System of national accounts 2008 (SNA 2008). New York. At http://unstats.un.org/unsd/nationalaccount/docs/SNA2008.pdf [4 junio 2014]. Edens B., Hein L., 2013. Towards a consistent approach for ecosystem accounting. *Ecological Economics* 90, 41-52.

Hartwick J.M., 1990. Natural resources, nacional accounting and economic depreciation. *Journal of Public Economics* 43: 291-304.

Heal G., Kristrom B., 2005. National Income and the Environment In: Maler K.-G.,Vincent J. (Eds.), *Handbook of Environmental Economics*, vol. 3. Elsevier.

Hultkrantz L., 1992. National Account of Timber and Forest Environmental Resources in Sweden. *Environmental and Resource Economics* 2: 283-305.

Kriström B., Skanberg, K., 2001. Monetary forestry accounting including environmental goods and services. *Investigación Agraria: Sistemas y Recursos Forestales* 1: 7-26.

Mäler K.G., 1991. National accounts and environmental resources. *Environmental and Resource Economics* 1: 1-15.

Matero J., Saastamoinen O., 2007. In search of marginal environmental valuations -- ecosystem services in Finnish forest accounting. *Ecological Economics* 61: 101-114.

Obst C., Edens B., Hein L., 2013. Ecosystem Services: Accounting Standards. *Science* 342 (6157): 420.

Obst C., Vardon M., 2014. Recording environmental assets in the national accounts. *Oxford Review of Economic Policy* 30 (1), 126-144.

Ovando P., Campos P., 2016. Renta y capital del gasto público en los sistemas forestales de Andalucía. In: *Valoración de los servicios públicos y la renta total social de los sistemas forestales de Andalucía* (Campos P., Caparrós A., eds). Memorias científicas de RECAMAN. Vol 5. Memoria 5.3. Editorial CSIC, Madrid.

Ovando P., Oviedo J.L., Campos P., 2016. Measuring total social income of a Stone pine afforestation project in Huelva (Spain). *Land Use Policy* 50, 479-489.

Remme R.P., Edens B., Schröter M., Hein L., 2015. Monetary accounting of ecosystem services: a test case for Limburg Province, the Netherlands. *Ecological Economics* 112, 116-128.

Solow R.M., 1986. On the Intergenerational Allocation of Natural Resources. *The Scandinavian Journal of Economics* 88(1): 141-149.

Stiglitz J. E., Sen A., Fitoussi J.P., 2009. *Report by the Commission onthe Measurement of Economic Performance and Social Progress*. At http://www.stiglitz-sen-fitoussi.fr/documents/rapport_anglais.pdf.

TEEB, 2010, The Economics of Ecosystems and Biodiversity: Mainstreaming the Economics of Nature: A Synthesis of the Approach, Conclusions and Recommendations of TEEB. Progress Press, Malta.

Train K., 2009. *Discrete Choice Methods with Simulation,* 2nd edition. Cambridge University Press, 383 pp.

United Nations, European Commission, International Monetary Fund, Organization for Economic Co-operation y Development, World Bank, 2003. Handbook of National Accounting: Integrated Environmental and Economic Accounting 2003 (SEEA 2003). At http://unstats.un.org/unsd/envaccounting/seea2003.pdf [22 may, 2014].

United Nations, European Commission, Food and Agriculture Organization of the United Nations, Organisation for Economic Co-operation and Development, World Bank Group 2014a. *System of Environmental Economic Accounting 2012—Experimental Ecosystem Accounting*. United Nations, New York.

United Nations, European Commission, Food and Agriculture Organization of the United Nations, Organisation for Economic Co-operation and Development, World Bank Group 2014b. *System of Environmental Economic Accounting 2012 –Central Framework*. United Nations, New York.

Vanoli A., 1998. Modelling and Accounting Work in National and Environmental Accounts. In K. Uno and P. Bartelmus, eds., *Environmental Accounting in Theory and in Practice*. Kluwer Academic Publishers, Dordrecht.

Vincent J.R., 1999. A Framework for Forest Accounting. *Forest Science* 45(4): 552-571.

Weitzman M.L., 1976. On the welfare significance of national product in a dynamic economy. *Quarterly Journal of Economics* 90: 156-162.

Appendix A: Wording used in the contingent valuation study

After a series of questions where the interviewee had to calculate the costs incurred during the current visit to the recreational area, taking into account all the people for which he had catered, the following wording was used for the entrance-fee question and the trip-expenditure question, respectively:

Entrance-fee question

Some natural areas (exceptionally in Spain and frequently in other countries) require an entrance fee for the purpose of contributing to the management expenses of these areas. Suppose that in this forest they were to establish an entrance fee for adults (children under age 16 free).

We are now asking you to assume that the total expenses of your visit would have been increased by the payment of an entrance fee to visit this area, doing exactly the same activity and with the same people.

If the expenses of your visit would have increased by the payment of an entrance fee of X€ per adult, or a total increase of XX € for all the people for which you have paid, would you still have come today? Please take into account that we are asking you to imagine a real payment and that you could not spend the money in alternative uses.

Trip-expenditure question

As you know trip costs have changed in the last years (e.g, gas prices have gone up and down independently from the generalized increase of prices). Now we are going to ask you to imagine that total expenditures of your visit increase for this reason, doing exactly the same activity (same transport, same food . . .) and with the same people.

We are now asking you to assume that the total expenses of your visit would have been increased by an increase in the price of gasoline, doing exactly the same activity and with the same people.

If the expenses of your visit would have gone up by an increase in the price of gasoline of X€ per day, would you still have come today? Please take into account that we are asking you to imagine a real payment and that you could not spend the money in alternative uses.

Appendix B: The Agroforestry Accounting System (AAS)

We present our results using the Agroforestry AAS (see Caparrós et al. (2003) and Campos and Caparrós (2006) for details), which does not follow the classification of institutional units applied in the official SNA for estimating the total social income. In contrast to the SNA, the AAS reorganises the conventional institutional units of the government and farmers into a single independent economic unit: the forest ecosystem. This procedure allows the estimation of the Net Value Added (NVA) by single activity, to which both private and public outputs and costs are assigned.

The AAS accounting framework has a production account and a capital sheet account. The production account incorporates all the economic flows related to natural occurring and cultivated production processes that occur during the accounting period. Stock values and their variations are recorded in the capital account, allowing the estimation of capital gains.

Using the appropriate identities (Caparrós et al., 2003) the production and the capital accounts allow the estimation of the Hicksian income, although we focus here on Net Value Added as capital gains are not especially relevant for the activity considered.

NVA is defined as *NVA=NOM+L*, where *NOM* stands for Net Operating Margin and *L* for Labor. By the same token, *NOM* is given by: *NOM=TO-TC*, where *TO* stands for Total Output and *TC* for Total Costs (both concepts are further disaggregated in the production account, see Table 3). Assuming a given discount rate, environmental assets are estimated discounting future streams of environmental *NOM*.