Ecological Economics 139 (2017) 140–149

Contents lists available at ScienceDirect

Ecological Economics

journal homepage: www.elsevier.com/locate/ecolecon

Analysis

Simulated exchange values and ecosystem accounting: Theory and application to free access recreation

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A R T I C L E I N F O

Article history:
Received 16 December 2015
Received in revised form 19 April 2017
Accepted 19 April 2017
Available online 9 May 2017

Keywords:
Green accounting
Recreation
Non-market goods and services
Andalusia
AAS
SEEA
SNA
Forests
Discrete choice

A B S T R A C T

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 manner consistent with the 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 in which the demand is estimated using discrete choice methods. This 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.

1. Introduction

Ecosystems provide many goods and services that are relevant to society, and there is an increasing interest in scientific and political arenas to extend the System of National Accounts (SNA) to explain this contribution (Howarth and Farber, 2002; Heal and Kristrom, 2005; Stiglitz et al., 2009). The UN, European Commission, FAO, IMF, OECD and World Bank have recently presented a new version of the System of Environmental-Economic Accounting Central Framework (SEEA) (UN et al., 2014a) and the SEEA Experimental Ecosystem Accounting framework (SEEA-EEA) (UN et al., 2014b). The World Bank has also launched the ambitious WAVES programme to integrate natural capital accounting (using the SEEA) in decision making (Atkinson, 2010; World Bank, 2016). Their approach encompasses both ecosystem accounting and accounts from the SEEA Central Framework. Within the former, they have launched pilot applications in a handful of developing countries. At a national/regional scale, relevant accounting initiatives are the SEEA accounts in Australia (Obst and Vardon, 2014), the ongoing UK Natural Capital Accounts (ONS and DEFRA, 2017), the monetary accounting of ecosystem services in the province of Limburg, in the Netherlands (Remme et al., 2015), and the project RECAMAN in Andalusia, Spain (Campos and Caparrós, 2016). In Europe, there are also several physical and monetary ecosystem accounting projects running at supra national scale. See, for example, the KIP INCA project (European Commission, 2016). Within an extended cost-benefit framework,[1] a recent large-scale application can be found in the UK National Ecosystem Assessment (Bateman et al., 2013).

Although there is a range of supply side valuation methods, see Section 2.5, valuation of non-market goods and services produced by ecosystems has traditionally focused mainly on the demand side, by using non-market valuation techniques (Bateman et al., 2002; Bateman et al., 2013). The standard procedure consists of selecting a random sample of the population to be investigated and confronting respondents with a questionnaire in which they have to state their willingness to pay to support a programme that involves the provision of an environmental service. Data are then analyzed using multinomial logit models and their recent developments (e.g., mixed logit), which allow the estimation of the probability that a member of the sample (and indirectly the population) would be willing to pay a given amount of money for the provision of the environmental service. These probabilities are interpreted as a demand function that allows the estimation of the different Hicksian variations (which are equivalent to the consumer surplus if the income effect is small).

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[1] Ecosystem accounting and cost-benefit analysis have different objectives and are complementary (Edens and Hein, 2013; Remme et al., 2015; Obst et al., 2013). In the standard accounting framework, the goal is to structure data on current final consumption and own gross net investment. Cost-benefit analyses focus on the welfare changes associated to different alternatives.

http://dx.doi.org/10.1016/j.ecolecon.2017.04.011
0921-8009/

Hicksian variation estimates are relevant in cost-benefit analysis; however, for ecosystem accounting, one needs to distinguish the part that could, in fact, be internalized in terms of prices multiplied by quantities (see the recent discussion in Obst et al. (2016) on this issue). Therefore, Cairns (2003) proposed focusing exclusively on the part that can be internalized because this is the only part that is consistent with current estimates in the standard 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. Briefly, the method consists of using demand functions that are estimated using the non-market valuation methods described above to simulate the entire market (demand, supply and competitive environment) to obtain the market value that one could obtain from a given ecosystems service *if* it were internalized. An analysis of the relation between the SEV and the theoretical literature can be found in Caparrós (2010).

The SNA and the SEEA also exclude consumer surplus from their valuations; and propose the use of exchange values (UN et al., 2014b). For goods that are 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 Skanberg (2001), Campos and Caparrós (2006) or Ovando et al. (2016a, 2016b, 2017).

Observed prices and transactions are used in the SNA - SEEA framework in a variety of ways: (i) directly; (ii) by using prices from similar markets; (iii) by using observed prices for resources, and other assumptions, to estimate resource rents and net present values; (iv) and by summing observed costs to estimate the value of services not transacted on markets (primarily government services). See SEEA EEA Chapter 5 for details (UN et al., 2014b).

The SEV goes a step further and proposes to simulate exchange values for non-market ecosystem services for which no similar market exists. Although the need to exclude the consumer surplus in the context of ecosystem accounting has been discussed previously (Caparrós et al., 2003; Obst et al., 2016), the objective of this paper is to further develop the SEV methodology in the context of ecosystem accounting.

The plan for the remainder of this 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. Finally, Section 4 discusses the limitations and the advantages of the SEV and 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 forest products that are partially traded in markets in Sweden and Finland, respectively. However, there are other goods and services that are provided by ecosystems in which 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 variation measurement that is obtained with non-market valuation techniques. However, these welfare 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), it was stated that "[…] contingent valuation […] gives an average willingness to pay figure which includes an element of consumer surplus […]. This poses a problem […] because the national accounts exclude consumer surplus." More recently, Obst et al. (2013: 420) also argue in favour of exchange values, adding that the aim is to record output: "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) began 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), which is 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 non-linearities permits the aggregation of the 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 corresponds to a linear, and hence additive, index of intertemporal welfare (Cairns, 2001)). Thus, as noted 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), Caparrós (2010), Cairns (2003, 2008) and Obst et al. (2016)).

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; however, other non-market amenities could be treated in a similar manner. We first analyse the case of a linear demand function due to its simplicity and then extend the analysis to cover the case in which 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) to provide the free access recreational service are given by $C(q) = c_1 + c_2 q + (c_3/2)q^2$, where q are the number of visitors, C are total costs and c_i (for $i = 1, 2, 3$) are parameters.

2.1. Linear Demand Function

We assume that the site-specific demand for recreational access to the forest i (we eliminate the subindex i for simplicity), which is currently under free access, is given by $p = P(q) = \alpha_1 - \alpha_2 q$, where p is price, α_i (for $i = 1, 2$) are parameters and P is the demand function.

2.1.1. Perfect Competition

We start by assuming that the market structure is perfect competition. This implies 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.

If the market were under perfect competition, the equilibrium would be given by the intersection of $P(q)$ and $C'(q)$. Hence

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

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

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

From a national accounting perspective, one of the problems arising if costs are variable is that the new simulated market would imply fewer costs than those actually incurred by the agents (government and private agents). This problem does not arise when costs are assumed to