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Abstract

This study proposes a novel approach to estimating a travel cost model that accounts for intra-household resource allocation. We define it 'Collective Travel Cost Method' (CTCM). The technique is based on an analogy borrowed from the literature of collective household behavior and adapted to the recreational setting. Knowledge of the travel cost to the recreational site of each household member allows us to identify the sharing rule within the household and to estimate a collective Almost Ideal Demand System that takes into account the role of each member's preferences for consumption choices and how resources are allocated within the household. We show how to identify and estimate welfare measures, such as the equivalent variation (EV), to infer the Willingness-To-Pay (WTP) to access a natural park of each household member. Moreover, the development and estimation of the CTCM allows: (1) to test whether the WTP estimated by the traditional unitary TCM is significantly different from the WTP estimated by the CTCM; (2) to test whether two spouses have equal or different WTP to access the recreational site, and (3) whether the individual WTP estimated by the CTCM is significantly different from the WTP derived by applying the Contingent Valuation Method (CVM) on the same sample of individuals.

Keywords: collective model, compensating variation, equivalent variation, revealed preferences, travel cost method, Willingness-To-Pay.

JEL Classification: D13, Q26, Q51

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1. Introduction

Cost-benefit analysis has to be often undertaken when a change in policy affects the quality or the availability of environmental resources. It has been recognised that the value of these goods is not explicitly determined through market transactions and it is difficult to establish a monetary value for their access because of the absence of markets.

Economists have answered this challenge by developing alternative methods of valuing non-market goods. The Travel Cost Method (TCM) by Clawson and Knetsch (1966) aggregates visitors to a recreational site into their zones of origin and it explains the change in visitors rates from each zone by the travel cost, the income, the socio-demographic characteristics of visitors and the characteristics of the alternative sites. More research has provided extensions to the original Travel Cost Method. Research shows efficiency gains in estimating recreational demand models using the observations of individuals themselves rather than traditional zone averages (e.g. Brown and Nawas, 1973; Willis and Garrod, 1991).

We argue that the traditional Travel Cost Method is limiting in that it can reveal consumer preferences for non-market goods by only capturing family behavior. It assumes that a household acts as an elementary decision making unit where all resources are pooled. This approach is referred to as 'unitary.' A household is defined by Becker (1965) as a 'small factory.' It consists of individuals motivated sometimes by self-interest, other times by altruism and often by both, or as if they agree on the best way to combine capital goods, time and home production activities.

To the best of our knowledge, no papers exist that estimate the individual Willingness-To-Pay (WTP) for each household member by using only revealed preferences data or that apply a Travel Cost Method to a collective framework. Smith and Van Houtven (1998, 2004) describe the implications of the collective model of household behavior for methods used to estimate the economic value of non-market goods and Veronesi (2006) presents a collective recreational demand model that uses information about the travel cost of individuals living alone as if they were living in the family in order to identify the individual preferences of two spouses. Both studies do not present any empirical application of their models and they do not estimate any welfare measure.

Two are the main contributions of this paper to the recreational models literature: first, we show that a utility theoretic framework derived from the collective model theory originally proposed by Chiappori (1988, 1992) can be applied in a recreational setting by using revealed preference data from a travel cost survey; second, we show how to identify and estimate individual welfare measures, such as the equivalent variation (EV), to infer the WTP to access a natural park of each household member. We define the implemented method as 'Collective Travel Cost Method' (CTCM).

We adopt the identification strategy developed by Menon and Perali (2006). The minimal requirement information for the identification of the sharing rule that describes the allocation of resources among household members is to observe at least one assignable good. In the 'Collective Travel Cost Method' knowledge of the travel cost to the recreational site of each household member allows us to identify the sharing rule and to apply the CTCM. In particular, we estimate a collective Almost Ideal Demand System that takes into account the role of each member's preferences for trips to a recreational site and how resources are allocated within the household.

Finally, the development and estimation of the CTCM allows: (1) to test if the WTP to access a recreational site estimated by the traditional unitary TCM is significantly different from the WTP estimated by the CTCM; (2) to test whether two spouses have equal or different WTP to access a recreational site, and (3) if the individual WTP estimated by the CTCM is significantly different from the WTP derived by applying the Contingent Valuation Method (CVM) on the same sample of individuals. Does the CTCM disentangle the bundle between stated and revealed preference Willingness-To-Pay?

We find, (1) that the WTP obtained by applying the traditional TCM is significantly different from the WTP obtained by applying the CTCM; (2) that two spouses have significantly different WTP and (3) that TCM and CVM do not yield to statistically different results when we apply the collective TCM, while the difference is statistically significant when we apply the traditional TCM.

The paper is organized as follows: Section 2 presents an overview of the literature about individual versus household in non-market valuation and the collective nature of household decisions. Section 3 describes the basic structure of the Collective Travel Cost Method and describes the identification strategy of the sharing rule. Section 4 describes the empirical model used: the Collective Almost Ideal Demand System. Section 5 describes the data and the results. The last section concludes with suggestions for future research.

2. Literature Review

It is by now accepted that the distinction between individual and household in recreational models matters. Smith (1988) compares five methods for estimating travel cost recreation demand models with microdata and argues that a component of research strategy should involve 'systematic effort at understanding how individuals make their recreation choices and whether these are adequately described by any of these models' (p.35). In the context of contingent valuation, Quiggin (1998) considers whether the willingness-to-pay for the benefit generated by a public good should be elicited on an individual or a household level.

Other authors (e.g. Haab and McConnell, 2002; Bockstael and McConnell, 2006) recognize that they ignore the distinction between household and individual in their work. In particular Bockstael and McConnell (2006) note that 'the distinction between the individual and the household is a difficult one for which there is, to date, no adequate treatment. In the original paper on household production, Becker treated the household as the decision making unit, suggesting that intra-household allocations of consumption and production activities would be made 'optimally' (p.512). In the forty years since that paper, little progress has been made in explaining this intra-household allocation process or in reconciling the distinction between the household as decision maker and the individual members as consumers. We continue to use the terms individual and household interchangeably, but recognize that embedded in their distinction are potentially important considerations' (p. 8, Chapter 4).

In the framework of revealed preferences, the only papers that we could find specifically addressing these issues are McConnell (1999), Dosman and Adamowicz (2006), and Smith and Van Houtven (1998, 2004).

McConnell (1999) states that the fact that many studies do not distinguish between individual and household makes the empirical estimates ambiguous. Further, 'economists need to think carefully about the individual versus the household in designing surveys and in measuring welfare' (p. 466). He attempts to address this issue by developing a recreational model based on two spouses sharing income, household production and earning different wages. The limit in this approach is that the basic structure of the model is the unitary model that assumes income pooling, that a household has a single utility function and that there is not bargaining and intra-household allocation of resources between household members.

Dosman and Adamowicz (2006) examine the choice of two spouses for a vacation site. They investigate intra-household bargaining using stated and revealed preference data. They overcome the problem that individual preferences for the site are not observed using stated preference methods. They ask each partner to make choices in a stated preference experiment and they use these choices to develop estimates of the spouses' preference parameters. Then they construct a bargaining model where the household utility is defined as the weighted average utility of partners' preferences. Since the household decision about the vacation site is observed, they estimate the bargaining parameter as the value that provides the best fits between the actual household choice and the weighted utility. They find that the probability that the household will choose the husband's favorite vacation site is decreasing as the husband's income is increasing. While the wife's power for the vacation site decision is increasing as the partner's income is increasing. An explanation of this result is that the opportunity cost of time for the husband is higher and he spends less time in planning the vacation.

Smith and Van Houtven (1998, 2004) describe the implications of the collective model of household behavior for methods used to estimate the economic value of non-market goods and they focus on the collective model by Chiappori (1988, 1992) but they do not present any empirical application.

Chiappori (1988) proposes the first collective model, which is a static labor supply model. This model assumes that the objective function of the household is the weighted sum of the utility functions for each member's preferences. The weights represent the bargaining power of the household members in the intrahousehold allocation process. The rule that determines the sharing of total expenditure on private goods within the household is defined 'sharing rule'. The bargaining power is affected by exogenous variables, such as wages and non labor income, and by other variables called 'distribution factors' (Browning et al., 1994), which influence the decision process without affecting either the utility function or the budget constraint. Examples of distribution factors are tax laws that differ according to marital status and divorce law. Changes in these variables may effect outside opportunities of the household members and may have consequences in their bargaining power within the household. An increase in an individual's nonlabour income may shift bargaining power from one individual to the other and this affects the allocation of household consumption and labour supply (see Vermeulen, 2002 and Browning, Chiappori and Lechene, 2006 for a detailed overview of collective models).

In Chiappori's model and consequently in Smith and Van Houtven (1998, 2004)'s approach the sharing rule is identified up to a constant and it is estimated by using information on two exclusive goods privately consumed. Smith and Van Houtven consider the case of a two-member household where each individual consumes two private goods and in addition each person consumes one of these goods exclusively, for example man sport fishing and woman swimming in the ocean. Finally, both members consume a third private good. They analyze the case where one member engages in a specific recreational activity affected by a change in environmental quality, and the other member does not. The authors do not investigate the case when both household members are affected by the change in environmental quality. They point out that it is still possible to recover individual preferences but that the problem is more complicated.

Browning, Chiappori and Lewbel (2006) propose an alternative approach. They use household's consumption aggregate data of singles and couples. They note that 'In general, only household's total purchases are observed, and not their distribution and use among members.

This raises three questions. First, one has to identify individual preferences. Secondly, since the distribution of resources within the household is not recorded, it has to be identified from the aggregate household demand - a standard problem of the collective literature. Finally, household consumption entails shared consumption, and hence economies of scale and scope in consumption'. Browning, Chiappori and Lewbel show how to completely identify the joint consumption and the allocation of resources within a household by a consumption technology function and the sharing rule borrowed directly from Chiappori but without any assumptions regarding interpersonal comparability or utility cardinalizations. 'The idea of the consumption technology function is that features of household consumption such as economies of scale or scope, joint use of resources, etc., can be defined as a technology that describes the set of options for the joint consumption of goods that are available to household members' (Browning, Chiappori and Lewbel, p.5). The sharing rule describes the allocation of resources among household members. Browning, Chiappori and Lewbel's framework is similar to Becker (1965) model, except that instead of using market goods to produce commodities that contribute to utility, the household produces the equivalent of a greater quantity of market goods via sharing (Browning, Chiappori and Lewbel). The collective model accounts for the differences in preferences and consumption of the household members.

3. Collective Travel Cost Method and Sharing Rule Identification

In this section, first we develop a collective recreational demand model by applying the collective model of household behaviour of Chiappori (1988, 1992). We define it as the 'Collective Travel Cost Method' (CTCM) since we use the individual expenditure to visit a recreational site as necessary variables for the identification of the sharing rule. Then we describe the identification strategy of the sharing rule between household members developed by Menon and Perali (2006).

We consider a household consisting of two members, individual *r* ('the respondent' of an on-site survey, for example) and individual *s* ('the spouse'). However, we can interpret one of the utility of the two members as a joint utility function for all but one member of the household. For example, as we will see in our empirical application, one utility can represent the utility of the respondent to the survey and the other utility represent the joint utility of all the family members of the respondent (e.g. the spouse with the children).

Let the superscripts refer to household members and subscripts to goods.

Each household's member *i* (*i* = *r, s*) consumes assignable private goods $\mathbf{x^i} = \left(x_1^i, ..., x_N^i\right)$ at price $\mathbf{p^i}$ and composite goods $\mathbf{Q^i}$ ($\mathbf{Q} = \mathbf{Q^f} + \mathbf{Q^m}$). For simplicity, assume $\mathbf{Q^i}$'s price is normalized to unity.

Let $U^i(\mathbf{x^i}, \mathbf{Q})$ be the egoistic direct utility function of individual *i*.

<u>Assumption A1</u>: Each individual has a monotonically increasing, continuous twice differentiable and strictly quasi concave utility function[4] $U^i(\mathbf{x^i}, \mathbf{Q})$ over a bundle of *N* goods $\mathbf{x^i}$.[5]

<u>Assumption A2</u>: Given the budget constraint the household makes Pareto efficient decisions, i.e. the household choice of $\mathbf{x^r}$ and $\mathbf{x^s}$ maximizes the weighted sum of the individual utilities subject to the budget constraint:

[4] Individual utility are represented by egoistic preferences but it is not necessary to recover individual behavior. We could use a caring utility function $\tilde{u}^i = \tilde{U}^i\left[U^1\left(\mathbf{x^1}\right), U^2\left(\mathbf{x}^2\right)\right]$ without altering the conclusion of the model (Chiappori, 1992).

[5] For notational simplicity, we have suppressed the demographic variables that we will include in the empirical application.

$$
(1) \qquad \begin{aligned} &\max_{\mathbf{x}^r,\mathbf{x}^s} W = \mu U^r(\mathbf{x}^r,\mathbf{Q}) + (1-\mu) U^s(\mathbf{x}^s,\mathbf{Q}) \\ &\textit{subject to} \quad \mathbf{p}^r\mathbf{x}^r + \mathbf{p}^s\mathbf{x}^s + \mathbf{Q} = Y \end{aligned}
$$

where $\mathbf{p^i}$ is the vector of market prices for the goods consumed $\mathbf{x^i}$; Y represents the total household income, which is exogenous, and μ represents the Pareto weight with: $\mu \in [0,1]$. The Pareto weight can be seen as a measure of individual *r*'s bargaining power in the decision process. The larger the value of μ is, the greater is the weight that individual *r*'s preferences receive. If $\mu = 1$ then the household behaves as though individual *r* has the bargaining power in the family, whereas if $\mu = 0$ then it is as though individual *s* is the effective dictator. μ is assumed continuously differentiable in its arguments and it depends on a set of exogenous variables **z** that can affect the bargaining power in the household and the intra-household allocation of resources (Browning et al., 1994). If the variables **z** affect the balance of power μ without affecting preferences and the budget constraints, then these variables are defined as 'distributional factors'. Examples of distribution factors are non labor income (Thomas, 1990), individual wages (Browning et al., 1994), spouses' wealth at marriage (Thomas et al., 1997), the targeting of specific benefits to particular members (Duflo, 2000), sex ration and divorce legislation (Chiappori et al., 2002).[6]

In equation (1) W can be interpreted as 'a social welfare function for the household,' in which each household member has different bargaining power, or alternatively as some specific bargaining model (e.g. Nash bargaining). The assumption that the household outcomes are Pareto efficient does not exclude the situation of household experiencing marriage dissolution. The distributional factors can affect the threat points in the marriage and household members can

[6] See Chiappori and Ekeland (2006) for a general discussion.

be viewed as players of repeated games with symmetric information, and therefore efficiency is a reasonable assumption.

The household's behavior can be represented by a two-stage budget decomposition. Partners first divide household income Y between them according to some predetermined but unknown sharing rule ϕ. Then, once income has been allocated, each member chooses her optimal consumption bundle by maximizing his/her utility subject to the budget constraint based on their respective share of household income. The additive separable objective function in (1) implies that an equivalent statement for each household member's objective function can be written as follows

$$(2) \qquad \max U^i(\mathbf{x^i}, \mathbf{Q^i}) \text{ subject to } \mathbf{p^i x^i} + \mathbf{Q^i} = \phi^i$$

where ϕ^i is the fraction of shadow income allocated to member i, $\phi^1 + \phi^2 = Y$.

Under assumption A2 of Pareto efficiency solutions to the individual, problem (2) must be equal to those obtained solving the household problem (1).

Unfortunately, in practice we cannot observe these two artificial stages. We observe the individual and household choices $\mathbf{x^i}$ and **Q.** Menon and Perali (2006) show that this information is enough for identifying the sharing rule without the need of using distributional factors as Chiappori et al. (2002) do and without the computational burden of the identification strategy of Chiappori (1988, 1992) that requires the calculation of second derivatives. They show that their identification strategy brings to comparable estimates of the parameters of the sharing rule to these alternatives approaches. We follow Menon and Perali (2006) because in the recreational field it is not always easy to find distributional factors and because of their computational simplicity in the identification of the sharing rule.

3.1 Sharing Rule Identification

The identification strategy developed by Menon and Perali (2006) is based on a technique commonly used in the literature to include demographic or other exogenous effects into demand systems (Pollack and Wales 1981; Lewbel 1985), and to estimate household technologies (Bollino et al. 2000). While in this literature demographic variables interact with prices or income, in their case the unobservable sharing rule interacts with individual total expenditure *a la* Barten (Barten 1964; Perali 2003).

The minimal information required to identify of the sharing rule is to observe at least one assignable good or two exclusive goods. We define a good exclusive when it can be consumed only by one individual and not the other (e.g. female and male clothing). We define a good assignable if we know how much is consumed separately by each individual (that is $\mathbf{x}^{\mathbf{r}}$ and $\mathbf{x}^{\mathbf{s}}$ are observed). In the Collective Travel Cost Method knowledge of the travel cost to a recreational site of individual *r* (i.e. 'the respondent') and *s* (i.e. 'the spouse') allows us to identify the sharing rule.

The individual total expenditure in most cases is not observed. However, we can approximate it as $y^i = x^i + \left(\frac{Y-x}{2}\right)$, where x^i is individual *i*'s assignable expenditure, *Y* is household income, *x* is the assignable household expenditure $\left(x = x^r + x^s\right)$, and $\left(Y - x\right)$ represents the non-assignable household expenditure, which is divided by the total number of household members by assuming a uniform distribution between household members. In the recreational case the individual assignable expenditure x^i is derived by multiplying the individual's travel cost by his/her annual number of trips to the recreational site.

Assumption A3: Let the sharing rule of individual i be a continuous function of exogenous variables $\mathbf{z}$ and individual total expenditure y^i:

$$(3) \qquad \phi^i\left(\mathbf{z}, y^i\right) = y^i m^i(\mathbf{z})$$

where $i = r, s$; $m^i(\mathbf{z})$ is a scaling function such that $0 \le m^i(\mathbf{z}) \le \frac{\phi^i}{y^i}$ and $\mathbf{z}$ can include wages, prices, non labor income or other variables that can affect the intrahousehold allocation of resources or the bargaining between household members. In logarithm form the sharing rule becomes

$$(4) \qquad \ln \phi^i\left(\mathbf{z}, y^i\right) = \ln y^i + \ln m^i(\mathbf{z})$$

where we define $\ln m^i(\mathbf{z}) = \sum_{h=1}^{H} \gamma_h z_h$. This specification tells us that the sharing rule can be interpreted as a shadow income post-intrahousehold allocation. The function $m(\mathbf{z})$ describes the size and direction of the allocation of resources between household members. It also tells us that the amount of resources allocated to individual i is different from the amount that we observed the individual spending (y^r). For example the expenditure for a trip of individual r depends on observed costs such as gasoline and the time cost of the individual r going to the site, but it may also depend on the time cost of the other household member that may stay home to take care of the children. Further note that $m(\mathbf{z})$ is not constrained between [0, 1] because it interacts with the individual total expenditure y^i.

The objective of the identification strategy is to recover the partial effects of the sharing rule with respect to the exogenous variables $\mathbf{z}$. Menon and Perali (2006) show that the partial effects can be estimated directly from the structural functional form of demand equations. This approach has two main advantages: the first one is that it is computationally simpler than a reduced form approach, such as the one implemented by Chiappori et al. (2002), and the second one that it can be applied into estimations of complete demand systems, such as the one described and applied in the next sections.

In this section we present the identification of the partial effects of the sharing rule by using the structural specification of the recreational demand for trips to a natural park of household members *r* and *s*. Consider the following structural forms:

$$(5) \qquad N^r = \alpha_0 + \alpha_1 d^r + \alpha_2 p^r_{tc} + \alpha_3 \left(\ln y^r + \gamma_1 p^r_{tc} + \gamma_2 p^s_{tc} + \gamma_3 z \right)$$

$$(6) \qquad N^s = \beta_0 + \beta_1 d^s + \beta_2 p^s_{tc} + \beta_3 \left(\ln y^s - \gamma_1 p^r_{tc} - \gamma_2 p^s_{tc} - \gamma_3 z \right)$$

with $\ln \phi^i = (\ln y^i + \ln m^i)$; $\ln m^r = \left(\gamma_1 p^r_{tc} + \gamma_2 p^s_{tc} + \gamma_3 z \right)$ and $\ln m^s = -\ln m^r$: where N^r and N^s correspond to the annual number of trips to a recreational site of individuals *r* and *s*; d^r and d^s are demographic characteristics of each individual; p^r_{tc} and p^s_{tc} represent individuals *r* and *s*' travel costs; z are exogenous characteristics that can affect the intrahousehold allocation of resources (such as the number of children in the household or the presence of a disable), and y^r and y^s correspond to the total individual expenditures.

Define

$$(7a) \quad A = \frac{\partial N^r}{\partial \ln y^r} = \alpha_3; \qquad\qquad (7e) \quad E = \frac{\partial N^s}{\partial \ln y^s} = \beta_3;$$

$$(7b) \quad B = \frac{\partial N^r}{\partial p^r_{tc}} = \alpha_2 + \alpha_3 \gamma_1; \qquad\qquad (7f) \quad F = \frac{\partial N^s}{\partial p^r_{tc}} = -\beta_3 \gamma_1;$$

and

$$(7c) \quad C = \frac{\partial N^r}{\partial p^s_{tc}} = \alpha_3 \gamma_2; \qquad\qquad (7g) \quad G = \frac{\partial N^s}{\partial p^s_{tc}} = \beta_2 - \beta_3 \gamma_2;$$

$$(7d) \quad D = \frac{\partial N^r}{\partial z} = \alpha_3 \gamma_3; \qquad\qquad (7h) \quad H = \frac{\partial N^s}{\partial z} = -\beta_3 \gamma_3;$$

It follows that the parameters of the sharing rule and of the travel cost variables are identified as long as the partial derivatives of the recreational demand with respect to the individuals' total expenditure (i.e. $A = \alpha_3$, $E = \beta_3$) are known:

$$\begin{aligned} \phi^r_{p^r_{tc}} &= \gamma_1 = -F / E \\ \phi^r_{p^s_{tc}} &= \gamma_2 = C / A \\ \phi^r_z &= \gamma_3 = D / A = -H / E \end{aligned} \quad \text{and} \quad \begin{aligned} \alpha_2 &= B + AF / E \\ \beta_2 &= G + CE / A \end{aligned} .$$

Once the parameters are identified, the value of the site, which can be interpreted as the willingness-to-pay of the individual to access to the site, is derived by calculating the individual's consumer surplus (CS). The individual's consumer surplus is the area behind the individual's recreational demand for trips to the site and above the observed level of constant marginal travel cost p^i_{tc} to produce trips N^i. By assuming a Poisson distribution, the consumer surplus (CS) of each individual becomes

$$\text{(8)} \qquad CS^r = -\frac{N^r}{\alpha_2 + \alpha_3 \gamma_1} \qquad \text{and} \qquad \text{(9)} \qquad CS^s = -\frac{N^s}{\beta_2 - \beta_3 \gamma_2} .$$

4. A Collective Almost Ideal Demand System for Non-market Valuation

In our empirical application we assume that household members have preferences given by the Almost Ideal Demand System (AIDS) of Deaton and Muellbauer (1980). In this section we extend the AIDS demand system to a collective framework by including the sharing rule between household members. The knowledge of the sharing rule allows the estimation of the individual indirect utility function and the individual expenditure functions, which can be used to find individual's welfare measures such us the compensating variation and the equivalent variation.

We estimate the AIDS demand system because it has numerous advantages: it gives an arbitrary first-order approximation to any demand system; it satisfies the axioms of choice; it does not impose any *priori* restriction on the elasticities; it has a functional form which is consistent with known household-budget data; it is simple to estimate, largely avoiding the need for non-linear estimation; and it can be used to test the restrictions of homogeneity and symmetry through linear restrictions on fixed parameters (Deaton and Muellbauer, 1980).

We choose the complete demand system specification to the single demand equations described in the previous section because the estimation only of single demand equation ignores interactions between demands of commodities and this may give us a wrong picture. By incorporating the budget constraint into the analysis, the complete system approach instead forces recognition of the fact that an increase in expenditure on one consumption category must be balanced by decreases in the expenditure on others.

Moreover, the complete system approach permits the separation of demographic effects from own and cross price effects as well as income effects. We propose the Barten-Gorman translating method, which translates the budget line through the fixed cost element, as a general method for incorporating demographic variables into complete systems of demand equations (Pollak and Wales, 1978). If we focus on visitor's expenditure, we can identify at least three variables significantly affecting patterns of spending: income, prices and socio-demographic characteristic of the visitor. A demand system which incorporates demographic variables helps to examine these effects at the same time.

Assumption A4: Individuals ($i = r, s$) have demand functions given by the integrable AIDS demand system.

Assumption A5: The Translog price aggregator $A^i(\mathbf{p})$ and the Gorman scaling demographic term Δ^i are equal across household members, that is $A^r(\mathbf{p}) = A^s(\mathbf{p}) = \frac{1}{2}A(\mathbf{p})$ and $\Delta^r = \Delta^s = \frac{1}{2}\Delta$.

Proposition P1: Let Assumptions A1, A2, A3, A4 and A5 hold. If individual *r* and *s*' expenditures in at least one assignable good or two exclusive goods are observed then the sharing rule ϕ^i, the individual indirect utilities $V^i\left(\mathbf{p},\phi^i\right)$ and the individual expenditures functions $E^i\left(\mathbf{p},U^i\right)$ are identified.

As showed in the previous section, for non-market valuation of a recreational site the travel cost to the site of individual *r* (the respondent) and *s* (the spouse) can be considered assignable and it can allows us to identify the sharing rule.

Let individual *i*'s indirect utility function be

$$(10) \qquad V^i\left(\mathbf{p},\phi^i\right) = \frac{\left[\ln\left(y^{*i}\right) - \frac{1}{2}A(\mathbf{p})\right]}{B^i(\mathbf{p})}$$

where

- $\mathbf{p}$ is the price vector of goods *k-th*,

- $\ln y^{*i} = \ln\phi^i - \frac{1}{2}\Delta$, with $\Delta = \sum_{k=1}^{N} t_k(d)\ln(p_k)$ and $t_k(d) = \sum_{h=1}^{H} \tau_{kh} d_h$ be a scaling demographic function with *d* socio-demographic variables, and p_k the price of good *k*;

- $\ln\phi^i\left(\mathbf{z}, y^i\right) = \ln y^i + \ln m^i(\mathbf{z})$ by Assumption 3 and Equation (4) with $\ln m^i(\mathbf{z}) = \sum_{h=1}^{H}\gamma_h z_h$; y^i individual *i*'s total expenditure; $\mathbf{z}$ exogenous variables that affect the distribution of resources within the household;

- $A(\mathbf{p}) = \alpha_0 + \sum_{k=1}^{N} \alpha_k \ln(p_k) + ½ \sum_{k=1}^{N} \sum_{j=1}^{N} \gamma_{kj}^1 \ln(p_k)\ln(p_j)$, and $B^i(\mathbf{p}) = \Pi_k \; p_k^{\beta_k^i}$.

By applying the duality relationship $E^i\left(\mathbf{p}, V^i(\mathbf{p}, \phi^i)\right) = y^i$ we obtain the associated log-expenditure function for individual *i*:

$$(11) \qquad \ln E^i\left(\mathbf{p}, U^i\right) = ½ A(\mathbf{p}) + U^i B^i(\mathbf{p}) + \ln m^i\left(z\right) + ½ \Delta$$

where $U^i B^i(\mathbf{p}) = \ln \phi^i - ½ A(\mathbf{p}) - ½ \Delta$.

By assuming that the household expenditure function is weakly separable the corresponding log-household expenditure function becomes

$$(12) \qquad \ln E\left(\mathbf{p}, U\right) = A(\mathbf{p}) + U^r B^r(\mathbf{p}) + U^s B^s(\mathbf{p}) + \Delta .$$

Roy's identity yields the collective system of share equations

$$(13) \qquad w_k = \alpha_k + t_k\left(d\ \right) + \sum_{j=1}^{N} \gamma_{kj} \ln\left(p_j\right) + \beta_k^r \left[\ln\left(y^{*r}\right) - A(\mathbf{p})\right] + \beta_i^s \left[\ln\left(y^{*s}\right) - A(\mathbf{p})\right].$$

The theoretical restrictions are homogeneity: $\sum_{j=1}^{N} \gamma_{kj} = 0;\ \sum_{h=1}^{H} \tau_{kh} = 0;$ adding-up: $\sum_{k}^{N} \alpha_k = 1;\ \sum_{k}^{N} \beta_k = 0;\ \sum_{k}^{N} \gamma_{kj} = 0;$ and symmetry: $\gamma_{kj} = \gamma_{jk}$.

For non-market valuation this demand system includes the annual individual shares of household income that individual *r* and *s* spent for the recreational site. The vector of prices **p** includes the travel costs of individual *r* and *s* to the recreational site (p_{tc}^r and p_{tc}^s).

Once estimated this demand system we take the exponential of (11) to estimate the expenditure functions for individuals *r* and *s*. This allows us to find individual welfare measures such as the compensating variation (CV) and the equivalent variation (EV).

Let $p_{tc}^{i,1}$ be the choke price, which is the travel cost that drives at zero individual *i*'s demand for trips to the recreational site. Let $p_{tc}^{i,0}$ be the observed travel cost and $\mathbf{p}_{-1}^{0}$ the observed prices of all the other goods in the complete demand system with the exception of the travel cost. Let $U^{i,0}$ be the utility level of individual *i* at the observed travel cost $p_{tc}^{i,0}$, and $U^{i,1}$ the utility level of individual *i* at the choke price $p_{tc}^{i,1}$; $A(p_{tc}^{i,1}, \mathbf{p}_{-1}^{0})$ and $B(p_{tc}^{i,1}, \mathbf{p}_{-1}^{0})$ are defined as $A(\mathbf{p})$ and $B^i(\mathbf{p})$ above with the only difference that they are evaluated at the choke price $p_{tc}^{i,1}$. We have that the compensating variation (CV) and the equivalent variation (EV) can be written as

$$(14) \qquad CV^i = E^i\left(p_{tc}^{i,1}, \mathbf{p}_{-1}^{0}, U^{i,0}\right) - E^i\left(p_{tc}^{i,0}, \mathbf{p}_{-1}^{0}, U^{i,0}\right)$$

$$(15) \qquad EV^i = E^i\left(p_{tc}^{i,1}, \mathbf{p}_{-1}^{0}, U^{i,1}\right) - E^i\left(p_{tc}^{i,0}, \mathbf{p}_{-1}^{0}, U^{i,1}\right)$$

where

$$(16) \qquad E^i\left(p_{tc}^{i,1}, \mathbf{p}_{-1}^{0}, U^{i,0}\right) = \exp\left[\tfrac{1}{2} A(p_{tc}^{i,1}, \mathbf{p}_{-1}^{0}) + U^{i,0} B^i(p_{tc}^{i,1}, \mathbf{p}_{-1}^{0}) + \ln m^i\left(z\right) + \tfrac{1}{2}\Delta\right]$$

$$(17) \qquad E^i\left(p_{tc}^{i,0}, \mathbf{p}_{-1}^{0}, U^{i,0}\right) = \exp\left[\tfrac{1}{2} A(p_{tc}^{i,0}, \mathbf{p}_{-1}^{0}) + U^{i,0} B^i(p_{tc}^{i,0}, \mathbf{p}_{-1}^{0}) + \ln m^i\left(z\right) + \tfrac{1}{2}\Delta\right]$$

$$(18) \qquad E^i\left(p_{tc}^{i,1}, \mathbf{p}_{-1}^{0}, U^{i,1}\right) = \exp\left[\tfrac{1}{2} A(p_{tc}^{i,1}, \mathbf{p}_{-1}^{0}) + U^{i,1} B^i(p_{tc}^{i,1}, \mathbf{p}_{-1}^{0}) + \ln m^i\left(z\right) + \tfrac{1}{2}\Delta\right]$$

$$(19) \qquad E^i\left(p_{tc}^{i,0}, \mathbf{p}_{-1}^{0}, U^{i,1}\right) = \exp\left[\tfrac{1}{2} A(p_{tc}^{i,0}, \mathbf{p}_{-1}^{0}) + U^{i,1} B^i(p_{tc}^{i,0}, \mathbf{p}_{-1}^{0}) + \ln m^i\left(z\right) + \tfrac{1}{2}\Delta\right]$$

The policy maker can use the individual's equivalent variation in order to know his/her Willingness-To-Pay to access a recreational site. This information can then be used to regulate the access at the area or for example to target programs to individuals in certain recreational activities groups rather than to households.

5. Empirical Application

5.1 Study Site and Data Gathering

The sample is drawn from an onsite survey conducted by the Department of Economics of the University of Verona on the West side of Garda Lake in the Northeast of Italy from June to October 1997. This survey was part of an integrated analysis on the multi-functionality of the West Garda Regional Forest in order to define cooperative policies between institutions, local operators and visitors.[7] This area was picked because it was also felt that, due to Garda Lake's popularity with tourists from throughout the country and abroad, there would be sufficient variation in distance travelled, time and trip cost.

The respondent was asked to recall the number of annual trips made to the West Garda Regional Forest and the number of trips to other natural areas during the year. In order to double check the declared costs, visitors were asked to specify their place of residence, the distance travelled between the natural area and their residence, the journey time and for those who were on vacation, the distance from the forest to their vacation lodging.

Moreover, the following data were collected for the respondent: means of transportation used, number of passengers per means of transportation, how many family members and how many shared the expense of the trip; if stops were made at other places before going to the natural area; how many days the trip lasted, occupation, weekly number of hours of work, number of children less than 12 years old in the household, household income and monthly household expenditure in food and leisure. In order to estimate the expenditure on alternative sites, the visitor was asked about the distance from the residence, the number of visits to each site, the quality of the area and the purpose of the trip.

[7] For a detailed description of the survey see Tommasi and Veronesi (2006).

The survey was not conducted with the purpose to estimate a collective travel cost model and neither to compare the willingness-to-pay of two spouses. This implies that we do not have any socio-demographic information for the spouse of the respondent. But since each respondent was asked to recall how much he/she spent for the trip and how much his family spent for the trip in terms of food, lodging and transport this allows us to compute the respondent's travel cost and his/her family members' travel cost.[8] The knowledge of assignable expenditure represents the minimal requirement for applying the Collective Travel Cost Method, identifying the sharing rule and individual welfare measures. We select only married people and the total sample size becomes of 225 observations.

5.2 Parameter Estimates and Analysis

According to the idea of complete demand system visitors of the West Garda Regional Forest proceed to allocate total income among the broad groups food, leisure and other goods. They also decide how to distribute the expenditure for leisure in trips to West Garda Regional Forest, trips to other sites and other leisure.

In our empirical application $i = r$ refers to the respondent and $i = s$ to the group 'other family members', that is the spouse with children. The expenditure for leisure in trips to the West Garda Regional Forest is divided into the amount that the respondent declared to have spent for him/her

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[8] Several studies apply and compare different values to estimate the opportunity cost of time (for example Cesario, 1976; McConnell and Strand, 1981; Johnson, 1983; Smith et al., 1983; Chavas et al., 1989; Bockstael et al., 1990; McKean et al., 1996). In this study we evaluate travel time at one third of the respondent' wage rate (Cesario, 1976) and we assume that respondent and spouse have the same wage rate.

self and into the amount that his/her family members spent in trips to the West Garda Regional Forest[9].

The vector of budget shares **w** consists of the shares of total household income that the respondent and the other families members spent into trips to the West Garda Regional Forest (respectively, *Garda_trips_r* and *Garda_trips_s*), and of the shares of total household income that the household spent in food (*Food_hh*), in trips to other recreational sites (*Other_trips_hh*), in other leisure (*Other_leisure_hh*) and in other goods (*Other_goods_hh*).

The shares of each good are specified as a system of equations according to the Collective Almost Ideal Demand System described in equation (13) of Section 4.

Table 1 and 2 present the descriptive statistics for the selected variables.

Table 1 - Definition of the variables in the collective AIDS demand system

Table 2 - Descriptive statistics for variables in the collective AIDS demand system

The independent variables included in the collective AIDS model are the logarithm of the prices of the goods, if the respondent is male and if he/she is Italian, respondent's age and number of years of education, the number of family members, if there are dependent children

[9] In order to find the annual expenditure for leisure in trips to West Garda Regional Forest we multiply the travel cost of one visit by the annual total number of trips to the natural area. In the case of the spouse we simulate the annual total number of trips by predicting the probability that the respondent travels alone, with and without family members and by multiplying this probability by the total number of trips.

less than 12 years old and how long the visit to the West Garda Regional Forest lasts. We use the logarithm of the expenditure as an approximation of the price for each good.

Zero observed shares such as the household share expenditure for other recreational sites or the other family members' share expenditure in trips to the West Garda Regional Forest are corrected by the Heckman two-stage estimation procedure described in the Appendix[10]. If only nonzero visit observations are used in the parameter estimation, ordinary least square procedures would yield inconsistent estimates from selectivity bias.[11]

Table 3 shows the estimated parameters. The signs are consistent with the underlying theory. In general the price parameters are significative and the respondent's demographic variables significantly affect the expenditure shares of trips to the West Garda Regional Forest with the exception of respondent's age and education: for example the presence of children or the fact that the respondent is male has a positive statistically significant effect (respectively at the 5 and 1% level) on the individual expenditure share of trips, *ceteris paribus.*

Table 3 – Estimates of the collective AIDS demand system

[10] In order to apply this procedure we create dummies variables equal to zero when the expenditures are zero and equal to one otherwise. As instruments we use the distance from the place of residence, the total number of hours that the respondent would have wished to spend at the recreational site, the total number of hours that the respondent would have wished to spend in hunting, fishing or harvesting flowers and mushroom; and the total number of hours that the respondent spent at the site mountain biking, horse riding, hiking, picnicking and visiting historic places.

[11] Full Information Maximum likelihood estimates for the collective AIDS demand model were obtained using the maximum likelihood routine in the computer package Gauss and after having dropped one of the six share equations, namely, the expenditure share of other leisure. Barten (1969) shows that the results are invariant to the equation deleted. The coefficients of the deleted equation are easily calculated, since they are linear combination of the parameters of the share equations included.

Table 4 reports the income, demographic and compensated price elasticities computed at the mean of budget shares by using numerical procedures. The signs are as expected: positive for the income elasticities and negative for the own-price elasticities. The trips to the West Garda Regional Forest represent the most responsive goods to income and price changes while food the most necessary and less elastic good. The number of children and the family size has a positive impact on the trips to the recreational area and a negative impact on food. This is consistent with what found in other papers (e.g. Koc and Alpay, 2003; Arias et al. 2003).

Table 4 – Income, demographic and compensated price elasticities (at mean budget shares)

Respondent's number of trips to the West Garda Regional Forest is in a complementary-type relationship with the other family members' number of trips to the West Garda Regional Forest but it is a substitute for food and other goods. The duration of the visit to the natural area has a negative effect on the trips to the other recreational sites. The number of years of education of the respondent has a positive effect on his/her expenditure in trips to the natural area but a negative impact on the other family members' expenditure in trips to the same natural area.

5.2.1 The sharing rule

As Table 5 shows, we use as factors **z** that can affect the distribution of resources within the household the number of children (*num_children*), the respondent's wage (*log(wage_r)*) and an interaction term that captures if the respondent is hunter or fisherman and travels without family member (*huntfish*nofam*). The respondent's wage is significant at the 5% statistical level and it positively affects the sharing rule: respondents with higher wages tend to allocate more resources to themselves than to the other family members. The number of children affects negatively the sharing rule at the 1% significant level. Figure 1 shows the relative sharing rule (that is the sharing rule divided by total household income, ϕ^r/Y) by the number of children. As the number of children increases the share of resources allocated to the respondent decreases. This is consistent with our expectations since in our sample the spouse is also representative of the preferences of the children.

Table 5 - Sharing Rule Parameter Estimates

	Parameter		Std. Error
num_children	-0.4395	***	0.1384
log(wage_r)	0.6065	**	0.2826
huntfish*nofam	0.1671		0.2477

** Statistically significant at the 5% level;
*** Statistically significant at the 1% level;
Number of observations = 225

Figure 2 represents another interesting result. It shows how the estimated relative sharing rule varies in relation to total household income. As we can see, there is a clear decreasing relationship: if the household income increases the amount of resources allocated to the respondent decreases or, in other words, respondents of households with lower levels of total income have a lower propensity to transfer resources to the other family members.

Figure 1 – Relative sharing rule by number of children

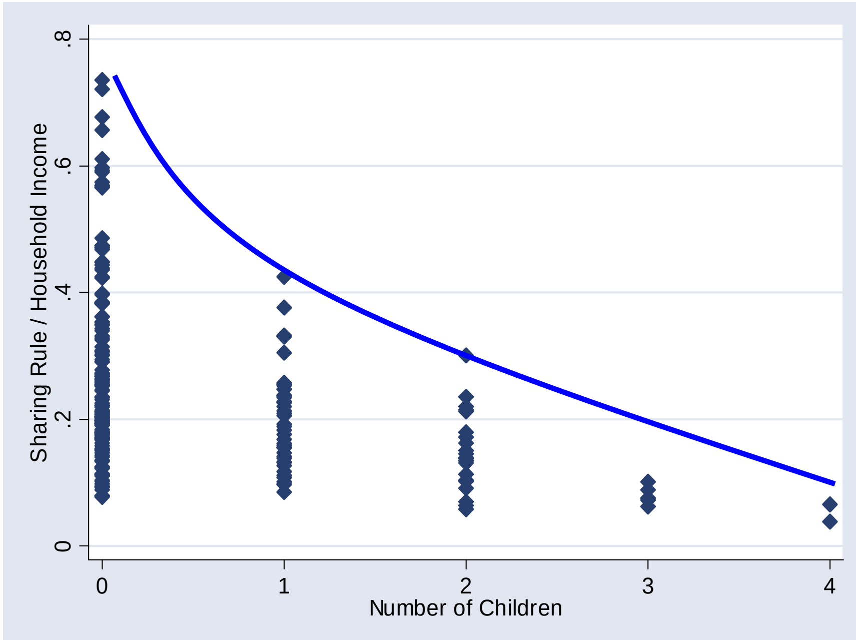
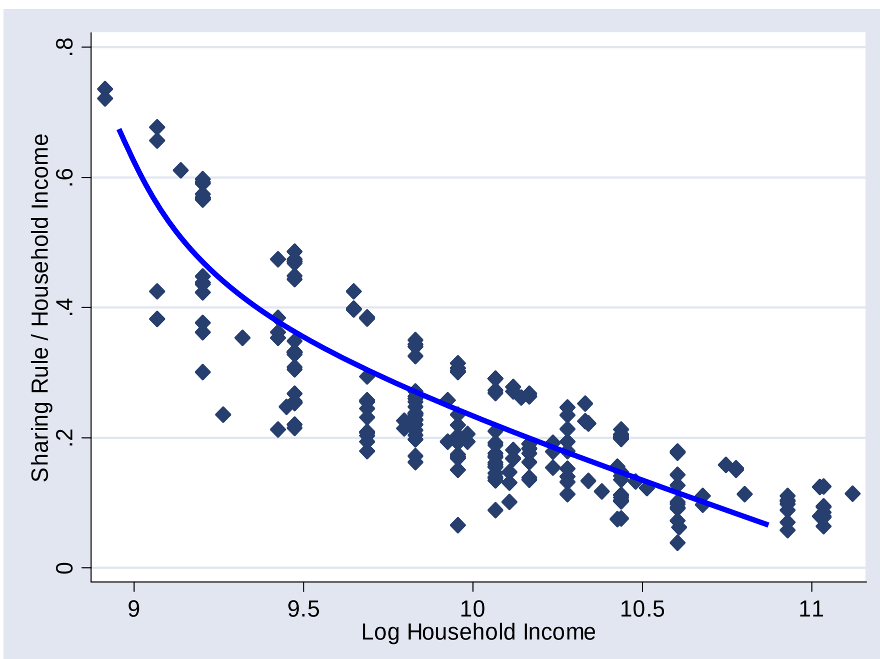


Figure 2 – Relative sharing rule by total household income



5.3 Welfare Comparisons and Individual Willingness-To-Pay (WTP)

The estimated collective AIDS demand system allows us to derive the individual expenditure functions for the respondent and the other family members by substituting the estimated parameters of Table 3 into Equations (16)-(19)[12]. Once we have estimated the respondent and the other family members' expenditures in order to find the equivalent variation we can apply Equation (14), which gives us the individual Willingness-To-Pay to access the West Garda Regional Forest. We define it *CTCM_WTP* since it derives from the application of the Collective Travel Cost Method[13].

Then we want to test: (1) whether the respondent's WTP per one trip to the recreational site estimated by the traditional unitary TCM (*TCM_WTP*) is significantly different from the respondent's WTP obtained by applying the CTCM (*CTCM_ WTP)*; (2) whether two spouses have equal or different WTP to access the recreational site, and (3) whether the respondent's WTP estimated by the Travel Cost Method is significantly different from the WTP derived by applying the Contingent Valuation Method (*CVM_WTP*) on the same sample of individuals.

With regards to Test (1) Table 6 shows that the traditional TCM and the collective TCM give significantly different WTP estimates (at the 1% statistical level). In particular the traditional TCM, which does not consider the intra-household allocation of resources and it assumed that all the resources are pooled, overstates the WTP of the respondent.

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[12] The price $p_{tc}^{i,1}$, which drives the number of trips at zero, has been calculated by using numerical procedures.

[13] Note that the WTP figures that follow have been divided by the annual number of trips, so they refer to the WTP per one trip to the West Garda Regional Forest.

Table 6 – Test (1): Is the Willingness-To-Pay (WTP) figure from the traditional Travel Cost Method (TCM) equal to the WTP from the Collective TCM?

Test (1) Ho: TCM_WTP_r = CTCM_WTP_r					
		Mean	Std.Err.	95% Conf. Interval	
TCM_WTP_r	Respondent's WTP (traditional TCM)	6.5103	0.1985	6.1191	6.9015
CTCM_WTP_r	Respondent WTP (Collective TCM)	4.9369	0.4324	4.0849	5.7890
p-value = 0.0000					
Number of observations = 225					

With regard to Test (2), the null hypothesis of no difference in WTP between two spouses, that is the respondent and his/her spouse, is rejected at the 1% statistical level (Table 7). In order to test this hypothesis we selected households with only two family members. We find that the the respondent's WTP is higher than the WTP of the spouse. This finding seems imply that the respondent cannot be considered as the representative individual in the household (i.e. his/her WTP does not represent the WTP of the other household members) as the traditional TCM instead assumes.

Table 7 – Is the respondent's Willingness-To-Pay (WTP) equal to the spouse's WTP?

Test (2) Ho: CTCM_WTP_r = CTCM_WTP_s					
		Mean	Std.Err.	95% Conf. Interval	
CTCM_WTP_r	Respondent's WTP (Collective TCM)	13.3901	0.6877	12.0177	14.7625
CTCM_WTP_s	Spouse WTP (Collective TCM)	8.2947	0.2821	7.7317	8.8577
p-value = 0.0000					
Number of observations = 69					

Finally, with regard to Test (3) we want to compare the WTP estimate from the Travel Cost Method with the WTP estimate from the Contingent Valuation Method. These two techniques are both estimating the willingness-to-pay for access to a recreational site but they differ in their approach. The CVM uses stated preference data (or hypothetical data) while TCM uses revealed preference data (or actual data). In order to find the WTP from the CVM we applied the discrete choice CVM question format by Cooper et al. (2006) called “Fair-One-and-One-Half-Bound” (FOOHB). In the contingent valuation survey a hypothetical market scenario is described to each respondent. Then respondents are asked whether they would be willing to pay for an entrance ticket and they are allowed to choose whether they want to start the questioning process with the low bid or the high bid. In other words, in order to make the survey “fair” the starting price for the bidding process is chosen by the respondent and not by the interviewer.

Both TCM and CVM have limitations and advantages. Consequently to investigate their validity the comparison of the welfare estimates from both techniques has received considerable attention in the literature (see for example Bishop et al. 1983; Sellar et al. 1985; Carson et al. 1996).

As Tables 8 and 9 show, the difference between the WTP estimates from these two approaches is statistically significant at the 1% level if we apply the traditional TCM, while it is not statistically significant if we apply the collective TCM. The CTCM allows us to derive WTP estimates that are not statistically different from those derived by applying the CVM.

Table 8 – Test (3a): Is the respondent's Willingness-To-Pay (WTP) from the traditional TCM equal to the respondent's WTP from the Contingent Valuation Method (CVM)?

Test (3a) Ho: TCM_WTP_r = CVM_WTP_r					
		Mean	Std.Err.	95% Conf. Interval	
TCM_ WTP _r	Respondent's WTP (Traditional TCM)	6.5103	0.1985	6.1191	6.9015
CVM_ WTP_r	Respondent WTP (Contingent Valuation)	3.8477	0.0046	3.8387	3.8567
p-value = 0.0000					
Number of observations = 225					

Table 9 – Test (3b): Is the respondent's Willingness-To-Pay (WTP) from the Collective TCM equal to the respondent's WTP from the Contingent Valuation Method (CVM)?

Test (3b) Ho: CTCM_WTP_r = CVM_WTP_r					
		Mean	Std.Err.	95% Conf. Interval	
CTCM_ WTP _r	Respondent's WTP (Collective TCM)	4.9369	0.4324	4.0849	5.7890
CVM_ WTP_r	Respondent WTP (Contingent Valuation)	3.8477	0.0046	3.8387	3.8567
p-value = 0.6745					
Number of observations = 225					

7. Conclusions

This paper is intended primarily to show how to estimate welfare measure for individuals living in a couple by applying the collective model by Chiappori (1988, 1992) to a recreational setting through revealed preference data from a travel cost survey. In particular, by using the individual travel cost of the respondent and his/her household members we have estimated a collective AIDS demand system that takes into account the intra-household resource allocation. This allowed us to estimate the willingness-to-pay of the respondent and his/her spouse to access the West Garda Regional Forest in Italy. We defined the implemented method as 'Collective Travel Cost Method' (CTCM).

At this point one could ask if the distinction between the traditional TCM and the collective TCM is merely an academic curiosity, or if differences in how resources are distributed within households reflect appreciable differences in the welfare measures. We found that the traditional TCM overestimates the WTP of the respondent estimated by the CTCM and that the difference is statistically significant at the 1% level. Then we found that respondent and his/her spouse have different WTP to access the recreational site. This seems implying that the actual practice of picking an adult at random from the household as representative of the other family member preferences could not be justified.

Finally, we compare the respondent's WTP from the TCM with the respondent's WTP from a contingent valuation survey on the same sample of individuals. We find that the two methods do not yield to statistically different results when we apply the collective TCM, while the difference is statistically significant when we apply the traditional TCM.

In conclusion, this paper showed that the Collective Travel Cost Method developed in this study can be implemented to yield individual welfare estimates potentially very useful for policy analysis but the need for more appropriately designed surveys must be emphasized. In the future, nonmarket valuation researchers should aspire to apply the Collective Travel Cost Method with improved data that include more observations and information about the number of trips and the demographic characteristics of the respondent's spouse. By designing *ad hoc* questionnaires analysts may be able to provide policy makers with more efficient and accurate estimates of the value o public goods for each household member.

From a theoretical perspective, two assumptions should be relaxed in the future: first, the assumption that the utility function of the spouse refers to the joint utility function of the spouse and his/her children; and second that the model does not take into account the behavior of groups where individuals from different households choose to take a trip together. Relaxing these assumptions will be the subject of forthcoming research.

Table 1 - Definition of the variables in the collective AIDS demand system

Variable	Description
Shares	
Food_hh	Household annual expenditure share in food
Garda_trips_r	Respondent annual expenditure in trips to West Garda Regional Forest park
Ggarda_trips_s	Spouse annual expenditure share in trips to West Garda Regional Forest
Other_trips_hh	Household annual expenditure share in other recreational trips
Other_leisure_hh	Household annual expenditure share in other leisure
Other_goods_hh	Household annual expenditure share in other goods
Prices in Euros	
income	Household annual income
ln*p*(food_hh)	Log(household annual expenditure in food)
ln*p*(trips_r)	Log(respondent annual expenditure in trips to West Garda Regional Forest)
ln*p*(trips_s)	Log(spouse annual expenditure in trips to West Garda Regional Forest)
ln*p*(other_trips_hh)	Log(household annual expenditure in trips to other recreational sites)
ln*p*(other_leisure_hh)	Log(household annual expenditure in other leisure)
ln*p*(othergoods_hh)	Log(household annual expenditure in other goods)
Demographic variables	
sex_r	=1 if respondent is male; 0 if female
age_r	Respondent's age / 10
education_r	Respondent's number of years of school /10
famsize	Number of household members
children_d	= 1 if there are children < 12 years old in the household
nationality_r	= 1 if respondent is Italian
visit duration_r	Number of days of visit to West Garda Regional Forest
Sharing Rule's regressors	
num_children	Number of children in the household
log(wage_r)	Log(respondent's wage)
huntfish*nofam	Interaction term: huntfish = 1 if respondent is hunter or fisherman; nofam = 1 if respondent travels without family members

Table 2 - Descriptive statistics for variables in the collective AIDS demand system

Variable	Mean	Std. Dev.	Min.	Max.
Shares				
Food_hh	0.2602	0.1485	0.0321	0.7692
Garda_trips_r	0.0105	0.0182	0.0002	0.1751
Garda_trips_s	0.0024	0.0082	0.0000	0.1039
Other_trips_hh	0.0027	0.0041	0.0000	0.0231
Other_leisure_hh	0.0915	0.0715	0.0010	0.4689
Other_goods_hh	0.6328	0.1814	0.0476	0.9464
Expenditures and Prices in Euros				
income	25208.33	13526.17	7436.98	67490.59
ln*p*(food_hh)	8.4964	0.4623	7.2402	9.6482
ln*p*(trips_r)	3.5872	1.1810	0.0324	6.8009
ln*p*(trips_s)	3.1334	0.8982	0.9487	6.4838
ln*p*(other_trips_hh)	3.1157	1.1194	0.1865	6.0610
ln*p*(other_leisure_hh)	7.2969	0.8403	3.7213	9.7615
ln*p*(othergoods_hh)	9.4809	0.8215	6.4293	10.9347
Demographic variables				
sex_r	0.6178	0.4870	0	1
age_r	4.4418	1.1330	2.2	7.7
education_r	1.2342	0.4241	0.5	2.1
famsize	3.2489	1.0692	2	7
children_d	0.3333	0.4725	0	1
nationality_r	0.7822	0.4137	0	1
visit duration_r	5.6133	10.0772	1	90
Sharing Rule's regressors				
num_children	0.5067	0.8405	0	4
log(wage_r)	2.5213	0.5115	1.3541	4.0622
huntfish*nofam	0.0578	0.2338	0	1
Number of observations = 225				

Table 3 – Estimates of the collective AIDS demand system

		Dependent Variable: Expenditure share of																	
Variable		Food_hh			Garda_trips_r			Other_goods_hh			Garda_trips_s			Other_trips_hh			Other_leisure_hh		
		Param.		Std.Err.	Param.		Std.Err.	Param.		Std.Err.	Param.		Std.Err.	Param.		Std.Err.	Param.		Std.Err.
Constant	α_k	0.2745	***	0.0664	0.0477		0.0314	0.4138	***	0.0710	0.0075		0.0291	0.0267	***	0.0101	0.2298	***	0.0061
Prices																			
ln*p*(food_hh)	γ_{kj}	0.1780	***	0.0071	-0.0017		0.0023	-0.1513	***	0.0044	0.0001		0.0021	-0.0019	**	0.0009	-0.0232		0.0584
ln*p*(trips_r)					0.0037	**	0.0314	-0.0013		0.0017	0.0000		0.0010	0.0010	**	0.0004	-0.0017		0.0032
ln*p*(othergoods_hh)								0.1962	***	0.0039	-0.0032	**	0.0015	-0.0019	***	0.0006	-0.0385	***	0.0016
ln*p*(trips_s)											0.0038	***	0.0011	-0.0003		0.0004	-0.0004		0.0025
ln*p*(other_trips_hh)														0.0032	***	0.0004	-0.0001		0.0013
ln*p*(other_leisure_hh)																	0.0639	***	0.0027
	β_k^r	-0.0163		0.0108	0.0205	***	0.0050	-0.0093		0.0100	0.0103	**	0.0046	0.0028	*	0.0016	-0.0080	***	0.0005
	β_k^r	-0.0140	*	0.0081	0.0029		0.0053	0.0088		0.0101	-0.0018		0.0043	0.0003		0.0013	0.0038		0.0110
Demographics																			
sex_r	τ_{kh}	0.0035		0.0049	0.0063	***	0.0019	-0.0075		0.0049	0.0040	*	0.0023	-0.0002		0.0008	-0.0061		0.0074
age_r		-0.0030		0.0023	0.0000		0.0008	0.0019		0.0023	0.0004		0.0011	-0.0002		0.0004	0.0009		0.0052
education_r		-0.0043		0.0063	0.0003		0.0022	0.0071		0.0061	-0.0008		0.0031	0.0008		0.0010	-0.0031		0.0024
famsize		0.0027		0.0074	0.0150	***	0.0033	-0.0191	**	0.0095	0.0107	***	0.0033	0.0026	*	0.0014	-0.0119	*	0.0067
children_d		-0.0003		0.0084	0.0106	**	0.0043	-0.0082		0.0106	0.0147	***	0.0042	0.0015		0.0014	-0.0183	***	0.0079
nationality_r		0.0051		0.0078	0.0009		0.0030	-0.0048		0.0079	0.0039	*	0.0035	0.0018		0.0013	-0.0069		0.0086
visit length_r		-0.0029		0.0025	0.0061	***	0.0009	-0.0048	**	0.0025	0.0011		0.0013	-0.0008		0.0005	0.0013		0.0074

* Statistically significant at the 10% level; ** 5% level; *** 1% level; Number of observations = 225

Table 4 – Income, demographic and compensated price elasticities (at mean budget shares)

Income Elasticities

	Food_hh	Garda_trips_r	Other_goods_hh	Garda_trips_s	Other_trips_hh	Other_leisure_hh
Income	0.9422	1.6824	1.0039	1.4675	1.2264	0.997

Compensated Own and Cross Price Elasticities

	Prices					
Good k	Food_hh	Garda_trips_r	Other_goods_hh	Garda_trips_s	Other_trips_hh	Other_leisure_hh
Food_hh	-0.0451	0.0160	0.0808	0.0094	-0.0009	0.0004
Garda_trips_r	0.0090	-0.8506	-0.1388	-0.0525	0.0552	-0.1053
Other_goods_hh	0.0186	0.0114	-0.0542	0.0003	0.0021	0.0266
Garda_trips_s	0.1338	-0.1291	-0.7020	-0.3176	-0.0718	-0.0777
Other_trips_hh	-0.1618	0.1547	0.0296	-0.0711	-0.3685	0.0422
Other_leisure_hh	-0.0025	-0.0015	0.2171	0.0015	0.0045	-0.1754

Demographic Elasticties

	Good k					
Demographic variables	Food_hh	Garda_trips_r	Other_goods_hh	Garda_trips_s	Other_trips_hh	Other_leisure_hh
sex_r	0.0077	0.5698	-0.0119	0.8507	0.0007	-0.0738
age_r	-0.0118	0.0040	0.0029	0.0812	-0.0428	0.0103
education_r	-0.0156	0.0085	0.0112	-0.1720	0.1539	-0.0356
famsize	-0.0072	1.3971	-0.0303	2.2902	0.6040	-0.1434
children_d	-0.0161	1.0221	-0.0131	3.0170	0.3697	-0.2146
nationality_r	0.0160	0.1275	-0.0077	0.8053	0.3816	-0.0808
visit duration_r	-0.0158	0.5262	-0.0077	0.2635	-0.1333	0.0142

Appendix: Generalized Heckman procedure

The generalized Heckman procedure consists of transforming the censored equations into uncensored equations by using the appropriate correction. Following Arias et al. (2003), we consider the unconditional mean:

$$E[y_i \mid x_{it}] = E[y_i \mid y_i > 0]\Phi\left(\frac{f_i(x_i,\beta_i)}{\sigma_i}\right) =$$
$$= f_i(x_i,\beta_i)\Phi\left(\frac{f_i(x_i,\beta_i)}{\sigma_i}\right) + \sigma_i\phi\left(\frac{f_i(x_i,\beta_i)}{\sigma_i}\right)$$

where, φ and Φ are respectively the probability density function and the cumulative density function of a standard normal distribution, y_i is the endogenous variable corresponding to the *i-th* equation in the censored system, x_i is a vector of explanatory variables, β_i is a vector of parameters. Using the expression for the unconditional expected value of each endogenous variable we consider the following system of uncensored equations:

$$y_i = f_i(x_i,\beta_i)\Phi\left(\frac{f_i(x_i,\beta_i)}{\sigma_i}\right) + \sigma_i\phi\left(\frac{f_i(x_i,\beta_i)}{\sigma_i}\right) + \xi_i$$

where $\xi_{it} = y_{it} - E[y_i \mid x_{it}]$. This system can be estimated by limited maximum likelihood assuming that

$$\xi \sim MVN(0,\Omega)$$

where, ξ is a random vector whose *i-th* element is ξ_i. An important detail stressed by Arias et al. (2003) is that this is a straightforward maximum likelihood estimation since the latter system does not contain any censored equation.

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