Non-Market Valuation and the Household

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Abstract

The purpose of this paper is to describe the implications of the collective model of household behavior for the methods used to estimate the economic value of non-marketed environmental resources. The effects of public good and risk are considered, along with revealed and stated preference methods. To the extent the collective framework is adopted, then recover of individual preferences from household behavior requires distinguishing how preference and within household income allocations affect choices.

Key Words: benefit estimation, household behavior, collective model

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Table of Contents

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I. INTRODUCTION

Non-market valuation has largely ignored the collective nature of household decision making.[1] Over the past two decades labor economists have considered co-operative and non-cooperative models for household behavior, especially as they influence labor supply decisions.[2] This paper describes how the collective model of household behavior transforms the interpretation given to the methods used to measure the economic values of environmental resources. Both revealed and stated preference methods are affected. These conclusions follow from using Chiappori's [1988, 1992] collective model for household behavior to re-interpret how individual choices relate to consumer surplus measures.[3]

Generalizations to the way we describe household behavior and define benefit measures are warranted for several reasons. Most adults live within households. Their labor/leisure choices are conditioned by the presence of other adults and children.[4] Many of the measures

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[1] Quiggin's [1998] recent analysis of the implications of different definitions of altruism for individual and household willingness to pay is the only paper we could find specifically addressing these issues. His focus, in contrast to ours, is on contingent valuation and in comparing different conceptions of altruism within a unitary model. See Smith and Van Houtven [1998a] for a more detailed discussion of the contrasts between his approach and the one developed here.

[2] A good general overview of the issues is in Lundberg and Pollak [1996]. Bergstrom [1997] provides a somewhat more technical summary. Both reviews do not consider in detail the differences between alternative versions of the collective model. Recent papers by Apps and Rees [1997] and Chiappori [1997] have highlighted their respective differences.

[3] One aspect of these differences relates directly to the Hanemann-Morey [1992] discussion of partial and complete compensating variation measures. However, the results here are in principle stronger than what their analysis would imply. This follows because the Chiappori framework imposes a stronger separability condition (i.e. the household objective function is equivalent to additive separability) whereas Hanemann and Morey consider only weak separability.

[4] Kooreman and Kapteyn (K-K) [1987] provide one of the most detailed treatments of time spent in non-market activities for both husbands and wives. Their findings clearly suggest each partner's work/leisure allocations are affected by each person's own circumstances and that of their spouse.

used to estimate the economic value of improvements in environmental quality derive from the decisions people make in allocating their leisure time. Thus, it should not be surprising to find that the factors influencing intra-household decisions affecting work would also be important to the non-market valuation of environmental resources. Environmental pollutants also affect human health. These effects are usually described using models linking measures of morbidity and premature mortality to the exposures people have to those pollutants. Households adjust to health shocks by transferring money and time to their sick members, attempting to maintain their well-being (see Lillard and Weiss [1997] as one example). A framework that focuses exclusively on each individual would ignore how household mitigation can reduce individual losses due to pollution.

More generally, the household is an institution organizing its members' activities. Decisions about what is treated as the primitive consumption unit for the purpose of analysis--whether individual or household--influence the concept of Pareto efficiency.[5] This is not an issue for Becker's [1974] unitary model or Chiappori's [1988] collective model because both specifications imply an efficient allocation of resources within the household. Rather, it is one that can arise in a wide class of the bargaining models for households.[6]

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[5] This is actually part of a larger question. Within the economic framework used to define Pareto efficiency, children are not economic agents assumed to be capable of independent choices that serve their best interests. By adopting the Becker framework where we assume there is one altruist who takes account household members' well-being we avoid the problem. Once the collective model is adopted, it is reasonable to ask whether some households act to assure efficient allocations from society's perspective. Hamilton [1998] implicitly raises this question in considering the effects of violence on television for young children. He asks whether parent's efforts to acquire information and monitor behavior are consistent with an efficient response, given we "accept" empirical evidence that violent programming promotes violent behavior. Similar questions could be raised with second hand tobacco smoke, exposure to hazardous substances in drinking water or indoor air. Children's exposure time and responses may be greater than adults.

[6] Within the McElroy - Horney [1981] Nash bargained external or the Lundberg - Pollak [1993] internal threat point models, a Pareto efficient allocation (from the individual perspective) is not assured. In the static Nash bargaining models, the difficulties arise because of the interpretation given to the objectives of individual household members in relation to the bargained outcome. If we consider the bargaining model's objective function as a description of the negotiation process (rather than the objectives of the household), there are no specific problems posed with defining welfare concepts. To see this point consider the model with external threat point. The household is viewed as maximizing the gains realized over an alternative, exogenous default state subject to its budget constraints. If we treat $U^1(\cdot)$ and $U^2(\cdot)$ as to the two members' utility functions and T^1, T^2 as the utility they would have realized outside of the "marriage" (or the household relationship), then we can describe the household's objective function with the equation given below.

$$\text{Max} \quad (U^1(\cdot) - T^1)\,(U^2(\cdot) - T^2)$$

With this specification an important source of the economic gains to forming a household is the ability to share expenses on household public goods. This bargaining model can pose questions for applied welfare analysis. This depends on how we interpret the Hicksian surplus measures that can be derived from it. That is, we must consider whether the welfare measures are defined conditional to a bargained outcome for each individual (using individual preferences and reflecting the role of how bargaining outcomes change with the policy) or as a composite value to the household objective function.

The collective model also identifies another potential source of nonuse or passive use values. It is not based on altruism. Rather it results from a reallocation of non-wage income within the household. This change stems from an increase in a non-market environmental resource that provides use value for one household member but not the other. The reallocation may increase the other resources available to the nonuser.

Section II outlines the basic features of the "new" household models. It uses simple examples to describe how exogenous (to the household) changes in the provision of public goods or environmental risks can be analyzed in a collective model. Section III considers what the framework implies for environmental valuation, and the last describes some next steps in judging whether the collective model would be supported by empirical record.

II. MODELING A HOUSEHOLD FOR BENEFIT MEASUREMENT

Choices made within a household context can be made through some type of collective evaluation. There is nothing in the conventional model of consumer choice that precludes having an individual's response reflect links between household members. However, any "sorting out" of the elements in this process requires prior restrictions sufficient to permit one to describe how choices made in a household context are related to individual preferences. The collective model focuses on this issue by assuming that some rule for distributing power or income within the household is established prior to making consumption and labor supply choices. To illustrate the importance of these assumptions we begin with the unitary model.

A. Background

The most common framework in conventional demand theory treats the terms "household" and "individual" synonymously. A household is a collection of individuals that behaves as if they agreed on the best way to combine their time, incomes, and home production activities. Sometimes labeled the "unitary model", this approach implies income pooling (i.e., re-distribution of income within the household will have no effect on expenditure patterns). Several explanations for the unitary model have been offered, ranging from Samuelson's [1956] early consensus based explanation to Becker's [1974] "rotten kid theorem".[7]

By contrast, the "collective model" assumes the household is Pareto efficient subject to a pre-defined income allocation rule for how the non-wage income is distributed among members of the household (usually the husband and wife). The income sharing rule is a modeling device used to take into account the role of each member's preference for the observed consumption choices. The rule recognizes that the observed choices of each member depend on how disposable incomes are divided. Chiappori's [1988, 1992] model

[7] The Lundberg, Pollak, and Wales [1997] test of the income sharing hypothesis is one of the most widely cited test of the unitary model. It finds strong evidence rejecting the unitary model.

does not require that an income sharing function actually exist. He assumes that there are classes of processes that would be equivalent (in their choice outcomes) to what we would observe from having each individual's consumption decisions made subject to the sharing function for household income.[8]

The most direct way to compare Becker's unitary model with the Chiappori collective model is through the specification of household's objective function. For Becker, the decision maker has a preference function that is weakly separable in the consumption choices of each member of the household. These separable subfunctions are usually assumed to be the preference functions of each household member. Thus, the head of the household "cares" and this benevolence restricts how the marginal rates of substitution for the consumption of private goods by different members of the household relate to each other.

In its most basic form, Chiappori's model assumes that adult household members are not altruistic toward each other. This assumption, together with the requirement that the household is efficient, is equivalent to a situation where household choices could be described as the result of maximizing a strongly separable preference function, that includes the two partners' preferences. This formulation allows budget decentralization and explains the income sharing function as another way of characterizing the implications of strong separability.

Most descriptions of the collective model include two assumptions. The first concerns individual member's preferences for public goods. The contributions of public goods to individual well-being are usually assumed to be separable from private goods.[9] Second, applications avoid household production activities. This strategy arises because the model does not easily accommodate household production processes that yield a good or service which is not available on the market. In cases with household production the income sharing rule cannot be distinguished from individual preferences or the household production technology without specific restrictions to the sharing rules or the household production activities (see Apps and Rees [1997], Chiappori [1997]). Identification of the income sharing rule (up to an additive constant) and the recovery of individual preferences (up to a translation) relies on the separability of household members' utility functions and the assumption that there is at least one private good exclusively consumed by each individual.

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[8] The sharing rule is a reduced form relationship that can be assumed to be determined within a two stage game. The first stage determines the relative "weight" of each individual's utility in the household's objective function, and the second stage resolves consumption and labor supply decisions.

[9] Most of the collective models to date considering public goods have done so by including goods that are only public (i.e., non-rival) within the household, but that can otherwise be purchased in private markets. Dahlberg [1997] extends Bergstrom's [1989] results to discuss the relevance of such framework for the median voter model used to describe the demand for local public goods. None of these efforts have considered the role of environmental public goods within the framework.

Household production eliminates separability in choices. This is the reason it introduces a need for further identifying assumptions.

B. Applying the Collective Model with All Private Goods

Consider the case of a two member household where each individual consumes two goods, one of these is unique to each person, X^1 for individual one and X^2 for two. In labor applications X^1 and X^2 would correspond to each person's leisure. In environmental applications X^1 might be sport-fishing and X^2 swimming in the ocean. Such a specification would imply each household member had different preferences for outdoor recreation. A second private good, $Z=Z^1 + Z^2$ is allocated between them. This good could be food or the use of the household's car in a given time period. For this first example we assume that Z's price is normalized to unity. Total household income, y, is assumed to be given exogenously.[10] The Pareto efficient framework for the household is given in equation (1) with $U^i(X^i, Z^i)$, the ith individual's preference function. Notice that we can re-write this expression as $U^1(.) + \mu U^2(.) - \mu\bar{U}^2$. $\bar{U}^2$ is a constant. As a result, the model can be treated as maximizing a weighted sum of the two individuals' preference functions subject to the overall household budget constraint.

$$(1) \quad \text{Max}_{X^i,\, Z^i,\, i=1,2} \; U^1(X^1, Z^1) + \mu[U^2(X^2, Z^2) - \bar{U}^2] + \lambda\,[y - P_1X^1 - P_2X^2 - Z^1 - Z^2]$$

Chiappori's analysis demonstrates that this problem is equivalent to the solutions derived from either of the two individual choice problems, given in equation (1a) and (1b). This characterization is actually a special case of the budget decentralization results for strongly separable preferences (see Blackorby, Primont and Russell [1978]).

$$(1a) \quad \text{Max}_{X^1,\, Z^1} \; U^1(X^1, Z^1) + \gamma_1[s(P_1, P_2, y) - P_1X^1 - Z^1]$$

$$(1b) \quad \text{Max}_{X^2,\, Z^2} \; U^2(X^2, Z^2) + \gamma_2[y - s(P_1, P_2, y) - P_2X^2 - Z^2]$$

The indirect utility function corresponding to the problem in equation (1), v^1, is linked to the one defined by equation (1a), V^1, in a straightforward way, as given by equation (2):

[10] We could assume each individual contributes a different amount to the exogenous income. However, this does not change the basic structure (see Chiappori [1997]).

$$(2) \qquad v^1(P_1, P_2, y, \bar{U}^2) = V^1(P_1, s(P_1, P_2, y(P_1, P_2, U_0^1, \bar{U}^2)))$$

The recovery of the income sharing function from observed choices exploits this link for commodities we know are consumed exclusively by one of the two members of the household. For example, the Marshallian demands for X^1 and X^2 are given in (3a) and (3b):

$$(3a) \qquad X^1(P_2, P_2, y) = x^1(P_1, s(P_1, P_2, y))$$

$$(3b) \qquad X^2(P_1, P_2, y) = x^2(P_2, y - s(P_1, P_2, y))$$

Notice that the demand function for X^1 and X^2 on the right sides of equations (3a) and (3b) are written with lower case letters to distinguish what is observed (X^i) from the theoretical formulation of each individual's demand function (x^i). The right side reflects the effects of the income sharing rule. s (P_1, P_2, y) goes to individual one and the balance y- s (P_1, P_2, y) to two.[11] Assuming the amounts demanded of X^1 and X^2 are observed, then the importance of Chiappori's results stems from the ability to use them to recover <u>both</u> s(·) and the individual preference functions from these Marshallian demands.[12]

As a rule, Z^1 and Z^2 cannot be separately observed; the analyst observes the household's total demand for Z which is the sum of Z^1 and Z^2. Adding to the choices in the model requires more constraints to distinguish how each object of choice is influenced by the decision process.[13] To develop these relationships for this case, consider how X^1 responds to P_2 and y:

$$(4a) \qquad X^1{}_{P_2} = \frac{\partial X^1}{\partial P_2} = x^1{}_y \cdot s_{P_2}$$

$$(4b) \qquad X^1{}_y = \frac{\partial X^1}{\partial y} = x^1{}_y \cdot s_y$$

Equation (4a) reflects the restriction that individual one does not consume X^2. Equation (4b) follows from the assumed process through which income affects the resources each individual

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[11] $\bar{U}^2$ is not repeated in the development of $s(\cdot)$ until we consider benefit measurement within the model.

[12] The preferences are quasi-indirect utility functions comparable to what is recovered in Hausman's [1981] approach for measuring Hicksian consumer surplus with what is interpreted as a representative individual's Marshallian demand. As described below, the process requires isolating the relevant differential equation based on separating *x* and χ.

[13] This problem has some parallels to a discussion by Diewert [1997] associated with identifying Slutsky conditions from aggregate demand responses. Diewert demonstrates that if the number of individuals in the aggregate is less than the number of goods and we know the micro distribution of demands (across individuals) in some baseline state, then a Slutsky condition can be developed for the aggregate demand.

has available to spend. That is, the demand for X^1 responds to income depending on how individual one's share of household income changes with any change in household income. Thus, the observable properties of demand also reveal properties of the income sharing function.

By considering the properties of ratios of the derivatives of the observable household demand functions (in equations (5a) and (5b)) we can isolate ratios of derivatives involving just the income sharing rule.

$$(5a) \qquad a = \frac{X^1{}_{P_2}}{X^1{}_y} = \frac{s_{P_2}}{s_y}$$

$$(5b) \qquad b = \frac{X^2{}_{P_1}}{X^2{}_y} = \frac{-s_{P_1}}{1-s_y}$$

This permits us to, for example, recover the effect of income changes on the share of income received by each individual. The second derivative properties of the demand functions defined by the equations on the right sides of (3a) and (3b) allow us to determine all the partial derivatives of s (P_1, P_2, y) as follows. The first of these, s_y, is given in (6a). With it we can also recover s_{p_1} and s_{p_2} in (6b) and (6c):

$$(6a) \quad s_y = \frac{ab_y - b_{P_2}}{ab_y - b_{p_2} - ba_y + a_{P_1}} = \theta$$

$$(6b) \quad s_{P_1} = -b \cdot (1-\theta)$$

$$(6c) \quad s_{P_2} = a \cdot \theta$$

Because the term in the middle of (6a) (between the two equality signs) is derived from observed functions, we can use it with the first order properties of these demand functions. Recovery of the individual preference functions from observed behavior (as quasi-indirect utility functions) uses Hausman's [1981] basic logic for partial differential equations, with an amended version of Roy's identity. These amendments follow from the link given in equation (2). That is, considering $v^1_{P_1}$ and v^1_y we have:

$$(7) \quad v^1{}_{P_1} = V^1{}_{P_1} + V^1{}_y \cdot s_{P_1}$$

$$(8) \quad v^1{}_y = V^1{}_y \cdot s_y$$

It is possible to relate the indirect utility V^1 to observable demands using Roy's identity $\left(-V^1{}_{P_1} / V^1{}_y = X^1\right)$. Moreover, as already noted, we assume that both X^1 and X^2 are observed. Re-arranging (7) using X^1 we have equation (9):

$$(9) \qquad v^1{}_{P_1} = V^1{}_y\left(-X^1 + s_{P_1}\right)$$

Substituting for s_{P_1} and $V^1{}_y$ in terms of $v^1{}_y$ and the observable links between the demand functions and income sharing equations (i.e. $s_{P_1} = -b(1-\theta)$ and $s_y = \theta$) we have:

$$(10) \qquad -\frac{dy}{dP_1} = -\frac{v^1{}_{P_1}}{v^1{}_y} = \frac{X^1 - s_{P1}}{s_y} = \frac{X^1 + b(1-\theta)}{\theta}$$

Equation (10) is the partial differential equation to be used to recover $v^1(\cdot)$. A similar procedure yields $v^2(\cdot)$. The specifics of each depends on the form used for the model, including the specification for the determinants of the sharing function.[14]

C. Household Production in the Collective Model

Including the possibility for household production is desirable for many environmental applications because this format has been used to explain averting behavior (see Smith [1991]). This addition implies another use for each individual's time in the Chiappori framework -- allocations to home production. To illustrate this possibility, assume with our simple model X^1 and X^2 (which could be interpreted as the respective amounts of leisure time for each individual) can be allocated to produce something within the household. Some part of this produced service flow or household commodity is also assumed to contribute to each member's utility.[15] It is labeled H. The production function is given in equation (11):

$$(11) \qquad H = F(X^1{}_h, X^2{}_h)$$

where: $X^i{}_h$ is the amount of X^1 used in producing H,

$X^i - X^i{}_h$ is consumed by individual i.

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[14] This example provides one of the simplest versions of Chiappori framework and is based on his labor supply analysis (Chiappori [1988, 1992]). There are a number of alternative ways to derive comparable results. For example, one could introduce labor/leisure choices in addition to the exclusive consumption of X^1 and X^2 or assume knowledge of the non-wage incomes from each member of the household. Each specification yields some new information about the link between the income sharing rule and individual preferences. As Browning et al. [1994] suggest, it is also possible to include exogenous variables in the income sharing rule to help in identification.

[15] Of course, we could also assume that H is a non-rival good within the household. For our purposes this difference is not especially important because we do not observe the allocation of H between the members.

Without an exogenous market for H, this addition to the model has the effect of creating non-separabilities. That is, including each person's share of H in their respective preference function (or treating all of H as non-excludable within the household) is equivalent to introducing a non-separability. Individual one's utility now depends on the amount of individual two's resources spent in home production (i.e., X_h^2) and vice versa. When a market is assumed to exist for H, it defines an external opportunity cost (i.e., a market price for H) that allows the decision process for individual consumption of X^1 and X^2 versus household production of H to be separated.

To separate preferences from the income sharing rule, once we relax the assumption that a perfect substitute for H is available in some market, requires adding assumptions about the structure of that income sharing rule. One possibility would assume that s(·) is a function of the total income (wage and non-wage) associated with each member (see Chiappori [1997]). Alternatively, other exogenous factors could be assumed to affect the sharing rule (and not the preference function). One might assume that s(·) is influenced by the years a couple has been together or some other demographic characteristic. Equations (3a) and (3b) can be re-written as (3a′) and (3b′) with r designating the exogenous factor:

$$(3a') \qquad X^1(P_1, P_2, y, r) = \quad x^1(P_1, c(P_1, P_2), s(P_1, P_2, y, r))$$

$$(3b') \qquad X^2(P_1, P_2, y, r) = \quad x^2(P_2, c(P_1, P_2), y - s(P_1, P_2, y, r))$$

$c(P_1, P_2)$ corresponds to the marginal cost of producing H (assuming F(·) is homogeneous of degree in inputs). In this case separability of individual preferences (in X^1 and X^2) is not required to recover characteristics of the sharing rule, as illustrated in equations (12a) and (12b):

$$(12a) \qquad \frac{X^1{}_r}{X^1{}_y} = \frac{s_r}{s_y}$$

$$(12b) \qquad \frac{X^2{}_r}{X^2{}_y} = \frac{-s_r}{1-s_y}$$

s_y can be recovered as:

$$(13) \qquad s_y = \frac{-\left(\frac{X^2{}_r}{X^2{}_y}\right)}{\left(\frac{X^1{}_r}{X^1{}_y} - \frac{X_r^2}{X_y^2}\right)}$$

If the allocations of X^1 and X^2 to home production can be observed, then it is possible to distinguish household production from the income sharing rule.

D. Public Goods

Non-rival goods for household members and general public goods can create non-separabilities in the household decision process, if the amounts available are determined by household members. By contrast, when these amounts are exogenous (as they might be in the case of environmental quality), then the task of isolating the Hicksian marginal value of the public good is more complex than with the unitary model but not greatly different from other issues addressed within the collective model. Identification will depend on isolating plausible exogenous factors that influence the income sharing rule and not preferences.

With exogenously determined public goods we generally seek to distinguish their effects on the income sharing rule from the contributions they might make to the well- being of one or more members of the household. Measuring each individual's valuation of the public good requires this task as a first step. The next step would involve using one of the revealed preference assumptions, such as weak complementarity, to link the public good to an observable decision about a private good. One simple approach that illustrates how we use the structure to recover the income sharing and preference functions assumes the exogenous public good (q) is only important to one person, say individual two. In this case, the effect of q on the exclusive good for individual one (X^1) would be due completely to q's effect on the income sharing rule, as illustrated in equation (14):

$$X^1(P_1, P_2, q, y) = x^1(P_1, s(P_1, P_2, q, y)) \tag{14}$$

Given this characterization we know that equation (15) describes how X^1 changes with q:

$$\frac{\partial X^1}{\partial q} = \frac{\partial x^1}{\partial y} \cdot s_q \tag{15}$$

Using the same logic developed to estimate s_y from $\frac{\partial X^2 / \partial P_1}{\partial X^2 / \partial y}$, s_q can be estimated from $(\partial X^1/\partial q)/(\partial X^1/\partial y)$. Of course, this requires the maintained assumption that only one person in the household was concerned about q and it is possible to identify the person. A simple example of this case would be a situation where one member engages in a specific type of recreation that is affected by environmental quality and the other does not.[16]

In this example, under one conception of the elicitation process for measuring a person's WTP for a change in q, individual one would be willing to pay for an increase in q.

[16] Isolating the role of q in the demand for X^1 does not in itself assure we can measure the Hicksian value of changes in q (see Bockstael and McConnell [1993]). Estimating of compensating and equivalent variation requires that we address the task of determining individual demand and value for q. Here the conventional suite of *a priori* restrictions (e.g., weak complementarity, perfect substitution, etc.) can be considered.

However, in this case the apparent payment arises because we assume individual one responds with knowledge of how a change in q, that benefits individual two, will alter his share of household resources. Thus, while WTP is not due to his use, it is also not a non-use value as conventionally defined. To the extent increases in q enhance the use values for the commodity consumed by individual two (X^2), it may be possible for that individual to realize her initial utility level (prior to the exogenous increase in q) with less income. If individual two's utility is held at that initial level, we would then expect the amount of household income allocated to individual one to increase. $\int s_q dq$ is then the maximum amount individual one would be willing to pay for a small change, dq, in the environmental quality enhancing two's recreation. When both members of the household are affected, the problem is more complex but not impossible to resolve, provided we assume that q is not separable from private goods in contributing to each member's well being.[17]

In the case of a non-rival public good (labeled here as Q, to distinguish it from the exogenous public good) that can be "purchased" by the household, it is possible to identify the income sharing rule, but all private demands must be assumed to be conditional to the consumption of the public good (see Browning et al. [1994]). There are at least two ways of distinguishing individual preferences from the income sharing rule (aside from separability). Bergstrom [1989, 1997] proposed the first, requiring that one assume each individual's utility can be represented as a transferable function. In this case the household demand for the public good is invariant to the distribution of income among household members.[18] A second strategy would impose restrictions used in non-market valuation (e.g. weak complementarity or perfect substitution) to recover the role of Q in each person's preferences by linking it to private goods consumed by each individual. In principle these restrictions together with an

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[17] It is important to acknowledge that this requirement is the opposite of assumption of separability usually made in this literature. The reason for the difference stems from the distinction in the types of public good involved. In this case we considered a public good whose level cannot be influenced by the household members, and our task is to consider whether there is sufficient information to recover how q affects each individual's preferences. If we are prepared to assume enough links to observable private goods (i.e., specific types of nonseparabilities), then it is possible to recover measures of individual preferences for q.

For the case discussed by Chiappori [1992] Browning et al. [1994], Bergstrom [1989, 1997], and Dahlberg [1997], the public good is non-rival within the household but purchased at a price through some external mechanisms. Their goal was to focus on private goods, so separability assures that demands and relevant income sharing functions (associated with the private goods) will not be related to the price of the non-rival household public good.

[18] If Q is the non-rival household public good and M_i is the ith person's income or a Hicksian composite good includes all allocatable goods consumed by both individuals then the relevant transferable utility function is:

$$U_i = G(Q) \cdot M_i + f_i(Q, W)$$

where W is a set of demographic variables. The absence of an i subscript on G(Q) is deliberate. See Bergstrom [1989, 1997] for a more detailed discussion.

observable aggregate household demand for Q as a "purchased" good should be sufficient to recover each person's demand for Q.

E. Risk

Our discussion of the collective model to this point has ignored uncertainty. Environmental policies often involve environmental risks. Thus, it is natural to ask whether the collective model can deal with risks that affect one or more members of a household. A state preference approach is a straight forward way to consider the implications of an *ex ante* view of individual and household. Assume that there are no contingent claims markets. Option price is then the relevant welfare concept.[19] When the uncertain state affects both members of the household and there are choices that influence either the extent of its impact or the probability itself, this formulation implies the choice is analogous to a nonseparable public good.

In the simple case, where the uncertainty affects only one member, the individual influenced by the events at risk would have his (or her) utility function replaced by expected utility defined over the possible states of nature.[20] Identification of the income sharing function follows the same general logic as in the case of a public good affecting only one person. In a two state case we recover s_{π} (with π as the probability of a bad state and s_{π} as the effect of that probability on the income sharing rule) from the unaffected individual. The ability to separate this effect from underlying preferences depends on the use of *a priori* restrictions.

That is, if individual one faced the risk of two outcomes--a good and a bad state--(3a) and (3b) would include the probability, π, in one's demand (*ex ante*) for X^1 and in the sharing function as in (3a‴) and (3‴).

$$(3a''') \qquad X^1(P_1, P_2, \pi, y) = x^1(P_1, \pi, s(P_1, P_2, \pi, y))$$

$$(3b''') \qquad X^2(P_1, P_2, \pi, y) = x^2(P_2, y - s(P_1, P_2, \pi, y))$$

We have equation (16) to describe how the commodity demanded exclusively by the person experiencing the risk (X^1) responds to π :

$$(16) \qquad \frac{\partial X^1}{\partial \pi} = \frac{\partial x^1}{\partial \pi} + \frac{\partial x^1}{\partial y} \cdot s_{\pi}$$

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[19] See Graham [1981, 1992] and Smith [1987] for discussion of the issues in using the option price measure for *ex ante* welfare analysis.

[20] When only one person is affected this strategy assumes the household treats expected utility (for the member experiencing the risk) as equivalent to "certain" utility for the other member. One could certainly "build in" household attitudes toward risk that would alter this assumption.

Following the logic outlined in equation (6a) we can recover an estimate of s_y from the derivatives of (3a‴) and (3b‴) with respect to P_1, P_2 and y. The two terms on the right of equation (16) can be identified (i.e., given s_y we have $\frac{\partial x^1}{\partial y} = \frac{\frac{\partial X^1}{\partial y}}{s_y}$). This process allows (16) to be solved for $\frac{\partial x^1}{\partial p}$ as in equation (17):

$$(17) \qquad \frac{\partial x^1}{\partial p} = \frac{\partial X^1}{\partial p} + \frac{\partial X^2}{\partial p}\left(\frac{\frac{\partial X^1}{\partial y}}{\frac{\partial X^2}{\partial y}}\right)\left(\frac{1-s_y}{s_y}\right)$$

When the risk is non-rival, there is an argument in each member's *ex ante* utility function associated with the probability. Following the same logic as our earlier discussion of a public good within the household, we can identify *ex ante* demands for public goods as distinct from the income sharing rule. We also have the choice of treating the public good (or the risk) as exogenous. In this case, the same arguments for using restrictions from revealed preference approaches apply to *ex ante* valuation. They are somewhat different in this case because the form of the expected utility model itself imposes some additional structure (e.g., multiplicative separability).

Equation (17) suggests that we can recover from what is observed, individual one's *ex ante* demand for the good he (she) exclusively consumes. From this demand we can develop *ex ante* welfare measures for individual one, following the general logic (adapted for the case of expected utility maximization subject to a budget constraint) given in equation (10). Thus, in simple cases the household model readily accommodates policies that influence the probability of undesirable outcomes. It is possible to accommodate more complex cases. However, with each addition to the ways the risk or some other policy affects the members of the household, the analysis will require corresponding additional restrictions to separate each individual's preferences from the choice information we can observe (or elicit).

F. Benefit Measurement

The collective model implies that consumer surplus measures for household members are interrelated. This can be seen by comparing the surplus measure derived from different components of equation (2). Consider a price change from P_1^0 to P_1^1, where the amount of household income to individual one is held constant. The right term in equation (2) can be used to define, for fixed s, the compensating variation (CV_1) in equation (18):

$$(18) \qquad V^1(P_1^0, s) = V^1(P_1^1, s - CV_1)$$

If we hold individual one's utility constant, we must consider what is happening to the other household member. CV_1 is a conditional measure that depends on the distribution of income within the household. In this case, because individual two does not consume X^1, with s held constant, changes in P_1 will not affect individual two's utility when the distribution of household income is held constant. If the commodity was consumed by both individuals, then the welfare measure would imply the effects of the price change for individual two had not been taken into account. This would also be true for changes in an exogenous public good.

A second measure of the compensating variation would allow s(·) to adjust with changes in P_1. This is defined in equation (19).

$$(19) \qquad V^1(P_1^0, s(P_1^0, P_2, y, \overline{U}^2)) = V^1(P_1^1, s(P_1^1, P_2, y - CV_1^*, \overline{U}^2))$$

The links between CV_1^* and CV_1 are analogous to the partial/full CV link discussed by Hanemann and Morey [1992]. Their Theorem 1 bounds the respective measures (i.e., $CV_1 \leq CV_1^*$). There is one further assumption in our case -- individual two's utility level is held at $\overline{U}^2$. This conditionality implies we cannot consider re-allocation of well-being among household members in response to external policy changes.

To understand why, consider a simple example where we plot each household member's utility with different allocations of household resources in Figure 1. The objective function in equation (1) maintains that the analysis begins from an existing distribution of income that implies the second person is assured $\overline{U}^2$. $\overline{U}^1$ is the point on the Pareto frontier describing what individual one realizes when two is held at $\overline{U}^2$ and allocations of resources in the household are efficient. Now suppose there is an exogenous change that enhances the utilities that can be realized so the new utility possibility frontier for the household corresponds to the curve labeled II. Our analysis is based on the premise that $\overline{U}^2$ remains constant. In fact, for selections on II anywhere between A and B both members of the household would gain over the initial point. Unfortunately, we do not know how to describe which would be selected. The Chiappori model, as we developed it, holds U^2 at $\overline{U}^2$. To do otherwise requires a criteria to select among the points between A and B.

For the most part, benefit estimation for environmental policies gauges the worth of changes in exogenous variables to the household. Exogenous public goods, prices, or probabilities offer applications. Measurement questions concern whether the changes in public goods or probabilities are related (through restrictions on preferences or household technologies) to observable quantities. If they are related to goods that are allocated within the household, then the individual members' demand functions must be isolated from household choices. This implies the estimates of each individual's values for changes in q or π will depend on the assumptions used to identify the income sharing rule and to separate each

person's demand from the household's aggregate consumption. If the change is related to a commodity consumed exclusively by one member of a household, then the model's primary role is analogous to that found in comparisons of conditional to unconditional Hicksian welfare measures.

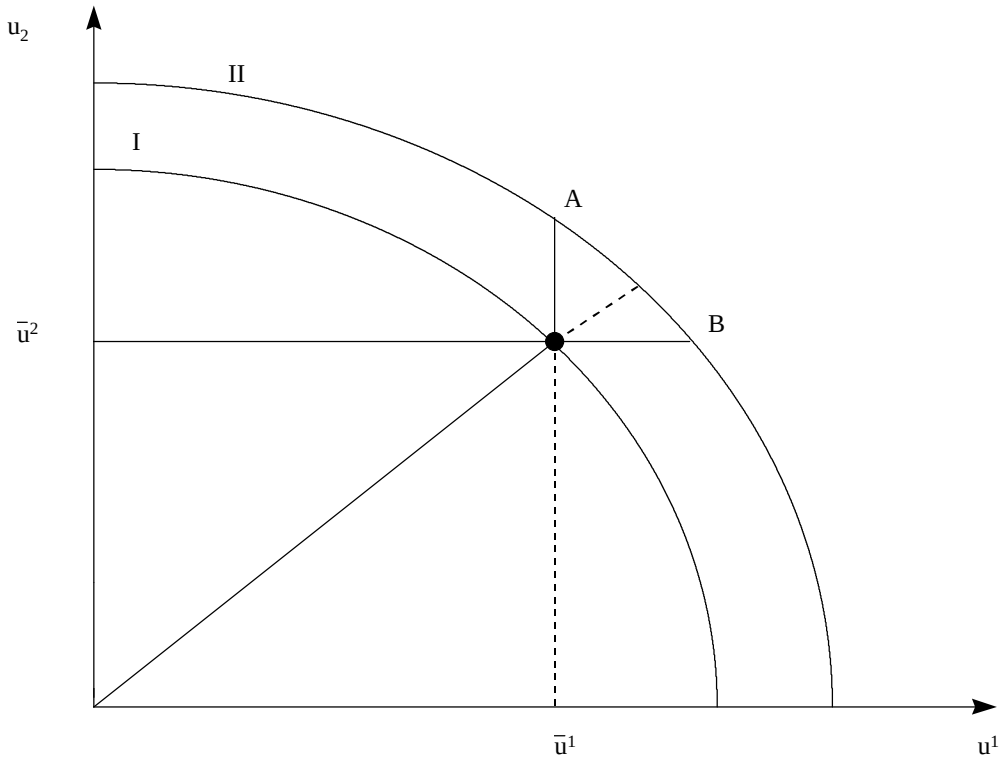

Figure 1: Household Utility Possibility Curves for Alternative Policies

G. General Implications

Adopting a household framework has implications for a wide range of practical decisions that are often made somewhat arbitrarily with both revealed and stated preference applications. Two examples may help to suggest further possibilities. Many applications of travel cost demand models are forced to consider cost allocation issues in imputing the "price" of a recreation trip. When an individual travels with a group to a recreation site, most analysts feel allocation of travel costs is warranted for groups that are not households. When the group is considered a household then all the cost is attributed to the respondent and there is also an implicit pooling of household resources into a single income measure. These distinctions are included in the data used for demand analysis and could well affect the estimates. We have

little basis for knowing whether they are reasonable.[21] Indeed, when group composition has been studied in random utility models of recreationists' choices of sport fishing sites, it appears to matter to the description of their decisions.[22] To our knowledge, these studies have not considered how a collective model would influence their cost assignment rules.

A second example involves the standard protocol for constructing a sample with in-person and telephone surveys. This procedure can call for: (a) enumeration of people in a household (usually but not always those living at a location); (b) identification of adults who contribute to the rent (or housing costs); and then (c) random selection of one member of that group for an interview. The collective model implies we may not be able to estimate individual benefit measures unless it is possible to collect information that reflects all members' incomes and factors influencing the income sharing rules. It is not clear that a random selection of adults will be the most effective strategy to collect this information. This has implications for both revealed and stated preference models used to evaluate environmental policies whose impacts could affect both preferences and income sharing functions.

Clearly other examples could be provided that identify other areas likely to be affected by a shift from a unitary to a collective perspective. Thus, this is not simply a matter of "layering" additional structure on the description of household preferences. It is relevant to the way data are collected.

III. DISCUSSION

One commentator on the importance of considering the implications of the collective model for benefit measurement has suggested that there is no role for decomposing benefit measures "below" the household level because policy is concerned with household resource commitments. Under this view it is argued that these resource commitments can be recovered from household demands without requiring a resolution of the unitary versus collective decision process. So there is no need to distinguish individual preferences from group decisions. There are at least three reasons why this view does not seem to be correct. First, at the most general level we should acknowledge that institutions (or rules) that constrain individual behavior condition the concept of Pareto efficiency.[23] Usually we equate these institutions with property rights but they could equally be treated as individual "roles" within a household. In certain economies, the choice process may not be one that is consistent with equality of members in the household. In such societies, a definition of Pareto efficiency

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[21] These imputations are analogous to the ones discussed by Randall [1994] in his critical evaluation of a wide range of judgments inherent in a travel cost model.

[22] Kaoru [1995] found in the context of a nested RUM travel cost model that the composition of a group--whether family, friend or business associates -- affected the length of trip and location for sport fishing.

[23] Buchanan [1962] first argued (to our knowledge) that the role of institutions generally (including property rights) was important to the definition of Pareto optimality.

focused at the individual level could well yield different benefit measures than one focusing at the household level. These differences are especially clear in efforts to apply stated preference methods in these settings. Interviews with different members will produce quite different descriptions of the "household" demand for sanitation and clean water as well as a wide range of environmental programs.[24] These differences should not be treated as reflections of the "vagaries" of stated preference methods but stem from differences in how the income shares are established and discretion available to some household members in comparison to others.

Second, as Quiggin [1998] suggests in a more general context, some of these differences can arise with the framing of choice questions and the extent of altruism within the household. With equal paternalistic altruism whose effects are confined to a non-rival good or with equal non-paternalistic altruism, the aggregate of each individual members' willingness to pay (WTP) across the members of the household will equal the household WTP. However, either form of individual benevolence can exist, and there still remain difficulties in measuring individual or household WTP. In the case of stated preference questions each requires some characterization of what is done (or will be done) to compensate or "tax" household members in response to how the proposal policy affects them.[25] For revealed preference methods we will not necessarily recover the same information when we recognize the differences that arise depending on whose behavior is used to attempt to recover household demands.

Finally, external constraints can impact different members of the household differently. These can be income tax systems, compensation and fringe benefit regimes or other rules that identify individuals within the household and create opportunities for internal adjustment and re-allocations (within the household).[26] Unless we distinguish each agent and their interactions with others, we do not have a basis for describing why two segments of a tax schedule should matter. The more restrictive assumption of a single preference function and income pooling by the household focuses attention exclusively on the sum of income. This implies quite different types of responses to the tax schedule.

Thus, observed responses to social norms, existing rules and institutions (including tax and benefit schemes), as well as people's understanding of the reports we request from them will

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[24] The valuation research undertaken on water and sanitation projects in developing countries provides clear examples of these distinctions. However, it is not limited to this. Indeed most of the applications of the collective model have arisen to date in modeling rural agricultural household choices in developing countries.

[25] The differences in responses found by Whittington et al. [1992] to allowing households time to consider a choice could reflect recognition of other members' constraints.

[26] One explanation for what was described as excessive estimates of the aggregate WTP in Australia to avoid development of a gold mine near the Kakadu National Preserve was the effect of the tax law on how respondents may have answered CV question. See Carson et al. [1994] for a summary of the study.

be interpreted differently with the orientation implied by the collective model. It is an empirical question as to whether the benefit measures will be greatly impacted by the distinctions.

IV. TESTING THE COLLECTIVE MODEL

It seems unlikely that a collective view of household choice would dramatically change the estimates of benefits derived from improvements in all environmental resources. As with some types of evaluations of individual of the labor/leisure choice the refinement may not always be important. However, for some problems--understanding women's labor supply choices with and without children present or household choices to reduce collective risks such as morbidity effects to parents and children, or the choices of infertility or birth defects, the effects may be large.

Under ideal circumstances, information would be collected from both partners in a household in order to evaluate which factors influence whether a collective view of household choice matters. This would parallel the approach taken by Kooreman and Kapteyn [1987] but would include information on other budgetary choices related to avoiding environmental harms or seeking environmental quality. Thus, one could envision analysis of single agent recreation demand models versus collective model specifications and tests of the cost allocation and income sharing conditions that would distinguish collective from individual choice. This could be extended to matched stated preference interviews with and without opportunities for coordination. The Roback [1982]-Rosen[1979] formulation of the hedonic model and implicit valuation of site amenities could be reconsidered with two wage models reflecting cases where the housing decision and the decisions for both jobs were changed simultaneously. Ideally this analysis would focus on dual earner households making these types of choices.

Of course, any one of these projects would be a large enterprise. Testing can proceed on a more limited scale by collecting information <u>from</u> <u>individuals</u> about household circumstances and the decisions that are likely to be related to the behavior, such as the labor/leisure choices of both members. Recovery of the income sharing function does not require knowledge of all the activities of the household and its members. It does require some information on <u>both</u> members. Thus, limited tests can proceed by reconsidering the information that is available. A major stumbling block that may affect some of these efforts (based on a non-systematic review of the data resources available to us) is the failure to decompose household income and to collect disaggregate information in ways that would allow estimation of household members' wage rates.

A recent pilot study investigating how the collective model influences individual and household demands for interventions that would reduce infertility risk (see Smith and Van Houtven [1998b]) suggests that even with individual responses it is possible to test some of the implications of the model provided we can successfully isolate the incomes of each member.

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