# Pricing What is Priceless: A Status Report on Non-Market Valuation of Environmental Resources

V. Kerry Smith

Abstract

This paper provides a selective overview of the modeling and estimates of the economic values of environmental resources. Travel cost, hedonic property values, contingent valuation and household production models are discussed and evaluated. Two new approaches - calibrated models and conjoint analysis - are compared with existing methods. For each class of models the review identifies some of the current research issues and potential areas for linking the results to policy.

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## I. INTRODUCTION

The theory and performance of the methods used for nonmarket valuation have been major preoccupations of environmental economists over the past decade. [1] This attention has been explained by a composite of public policy needs and the litigation based interest arising from natural resource damage assessments (in the United States).[2] While there is little doubt that these two areas have provided important demands for valuation information, it may also be useful to consider nonmarket valuation in the context of what might be described as the "larger landscape" of resource allocation decisions. Environmental resources, especially those providing amenities, seem to have become more scarce over the last half of this century. Most of this change has been due to the forces of economic growth raising incomes of households in more areas around the globe and, as a result, increasing their demands for the environmental resources embodied in local living environments and in resources supporting outdoor recreation. Both types of demands acknowledge that there are marketed goods and services demanded primarily when they can be combined with environmental amenities. Often the quality of the environmental resources involved influences the economic value people

place on these combinations of marketed and nonmarketed resources. For example, estimates of the full expenditures on outdoor recreation activities that use environmental resources (including time and travel costs, but excluding lodging and food), would also dwarf the GDP of a number of the developing nations. In the US alone 270 million visitors are expected to use national parks and forests during the 1996 summer season.[3] As this sector continues to grow in significance, it should not be surprising that there is ever increasing attention given to measures of the economic value of environmental resources [4] These resources serve as the equivalent of essential inputs to each household's production of the outdoor recreational activities that would comprise an important part of the tourism sector.

To meet these needs, both the historically developed and newly developed countries have increased the restrictions on emissions leading to pollution and on land conversions that threaten natural environments. Pollution control requirements have created an economic sector whose product demands derive from these requirements. In developed economies, it is a growing component of the manufacturing sector and therefore also has a "stake" in the indirect values assigned to environmental resources. Annual expenditures to control pollution in the developed world exceed the gross domestic product (GDP) of many developing countries.[5] These expenditures go to firms that develop, manufacture, and maintain environmental control equipment.

At a general level then one might interpret this interest as a reflection that the market oriented systems around the world are being forced (by growing demands) to find ways of reflecting the economic values of environmental resources available outside markets in the decisions that are made about how they are used and protected.

This paper provides a selective overview of what has been learned from efforts to develop monetary measures of the economic values for non-market environmental resources. It assumes a working knowledge of the theoretical principles underlying benefit measurement and highlights recent empirical developments in using indirect and direct methods for constructing these monetary measures. Section II outlines the typical objective -- to measure willingness to pay for a specified change in some environmental resource and then summarizes the approaches used by each method to accomplish this task. It provides a largely personal evaluation of what has been learned about the practice of using each method and concludes each subsection with a few suggestions for further research.

Section III considers two relatively new areas: calibration and conjoint analysis. Each has been proposed as offering insights (or approaches) that would improve upon existing methods for non-market valuation. The last section discusses how the uses of valuation estimates condition the way research is defined. It calls for different, less project oriented, approaches to research on benefit measurement.

## II. MONETIZING ECONOMIC VALUES

### A. Background

Beginning with the first edition of Freeman's The Benefits of Environmental Improvement: Theory and Practice in 1979, a variety of volumes have appeared in the intervening 17 years to enhance our overall understanding of the relationship between Hicksian and Marshallian measures of consumer surplus.[6] The analytical definitions of

monetary measures for the economic value of environmental resources usually treat these resources as rationed or quasi-fixed commodities. To define these measures more formally, assume $q$ designates the amount of one such resource (or a vector of resources) that is (are) available to an individual. It is assumed to be outside an individual's direct choice in the conventional definitions of economic value. In later sections of this paper this assumption is partially relaxed. Measures of economic value require that we observe people's choices, so our models will in fact assume some ability to select levels for $q$. As I develop below, the interpretation and measurement of $q$ has been often taken for granted.

In the literature as well as in the discussion of the concepts developed in the next few paragraphs $q$ will at times be referred to as an "amount" of the environmental resource or as a quality dimension of an environmental resource. These practices can be confusing until we consider the same types of issues associated with marketed goods. Quantities of any commodity consumed by people should not be "added up" unless they are exactly the same good. We encounter this issue when different types of the same commodity must be aggregated and these types vary in quality. Quantity and quality issues are interrelated. To adequately measure one it is essential to resolve how the other is measured and accounted for in any proposed quantity metric. At this stage in the development, having identified the issue, I will abstract from it, recall its relevance periodically and for now point out what is important about the role of $q$ in the description of consumer behavior. The definitions assume $q$ (whether quantity or quality) is <u>outside</u> an individual's choice and like each price will be treated as a parameter that affects choices.

The Hicksian willingness to pay (WTP) for an increase in one or more of these resources from $q_0$ to $q_1$ (with $q_1 > q_0$) is given in equation (1). *e(.)* designates the function that describes the minimum expenditures necessary to obtain utility level, $u_o$, given the quasi-fixed commodities, *q*, and the vector of prices, *p*, for the marketed goods consumed by an individual. It describes how expenditures change with changes in any of these three determinants (including *u*).

$$WTP = e(p, q_0, u_0) - e(p, q_1, u_0) \qquad (1)$$

The expenditure function cannot be estimated directly (Hausman [1981]), because the utility level realized in the baseline condition is not observed. Therefore it is convenient to recognize that this level of well-being is itself a function of the initial prices, initial level of environmental resource, $q_0$, and initial income ($m_0$).[7] Using this link(and the fact that $m_0 = e(p,q_0,u_0)$), we can re-write (1) as equation (2) in terms of observable variables.

$$WTP = m_0 - e(p, q_1, v(p, q_0, m_0)) \qquad (2)$$

where $v(p,q_0,m_0)$ is the indirect utility function

evaluated for the baseline condition (i.e., $p$, $q_0$, $m_0$).

Written in this form we see the arguments of equation (2) are, in principle, observable. WTP is not because $q_1$ is generally a proposed level, not one that has been realized. To measure WTP requires estimating what the expenditures with the environmental resource at the improved level would be. This is the point of any analysis of how people "use" environmental resources.

In most policy applications we do not observe how specific individuals will react to an improvement in environmental quality. Thus, there may be no convenient way to

observe the expenditures corresponding to $e(p,q_1,u_0)$ for the people whose WTP we wish to estimate. However, we may observe how different households have reacted to situations where the improved level of environmental quality was represented by $q_1$. For example, we might observe differences in households expenditures on health care associated with short-term morbidity episodes in areas with differing levels of air pollution. We could also consider the differences in distance traveled and other expenditures for specific types of recreation (e.g. sport fishing) for individuals in areas where the fishing opportunities (and quality) are different. Of course, as my examples suggest, they may also have different prices. In these circumstances, the restrictions we impose from economic theory become instrumental in using the choices across households to construct an estimate of the WTP. These types of assumptions are especially important for applications involving environmental resources, we rarely observe consumers confronting monetary tradeoffs directly associated with these resources.

The second and equally important issue with this definition of WTP relates to the measurement of $q$. Writing it as either a scalar quantity or a vector in equations (1) and (2) gives the impression it can be readily measured in a well-defined metric that is understood by people in the terms to define $q$. In practice, we do not know how people perceive environmental resources or how different amounts should be represented to capture the way each person experiences them.

This issue does not arise for most market goods because the quantity measures can be defined from their prices. Developing a demand model for a particular brand of apples (e.g., Macintosh or Golden Delicious), for example, does not require

understanding how people perceive the various types of apples. Rather we can observe how consumers respond to changes in their prices, using quantity measures as they have been defined in the pricing arrangements for these products.[8] If the needs of analysis are confined to understanding how a change in the price or income influences the quantity demanded (measured in these units), then incomplete information about how people perceive the "amount of apples" becomes unimportant. To understand why one type of apples serves as a better substitute for another or how demand would respond to a change in the attributes of a variety of apples requires a more fundamental knowledge of these perceptions.[9] The existence of pricing rules allows for "shortcuts" in the measures we accept as characterizing a consumer's preferences and is fundamental to the construction of quantity indexes.[10] As a rule, this advantage is not available for environmental resources. Indeed, it is fair to say that in many situations we don't have either quantity or price measures.

Finally, the last issue illustrated in equation (2) concerns the prospects for using assumptions about how q relates to private goods to estimate WTP. Substitution relationships are fundamental for measuring economic values. Tradeoffs describe what each individual will give up to obtain something else and isolate a bound for an economic value.[11] As a result the linkages based on some form of substitution or complementarity between one or more private goods and the non-marketed environmental resource are the basis for non-market valuation.

## B. Indirect Approaches for Non-Market Valuation - Theory

All monetary measures of economic value require a choice. Suppose, for example, we assume an individual could purchase an improvement in the environmental resource $q$ from $q_0$ to $q_1$. If this ($q_1$ - $q_0$) increment were offered for $S$ dollars, then an individual's decision would isolate either a lower bound or an upper bound for the Hicksian WTP. We can see this by recognizing that a decision to make the purchase implies WTP must be greater than (or equal to) $S$, and one rejecting it implies that WTP must be less than $S$. For first choice $S$ isolates the lower bound and the second (i.e., a rejection of the offer) an upper bound.

As a rule, we only observe choices involving private goods or services. Using them to estimate an individual's value for changes in a non-market environmental resource, that can be a public good, requires assumptions about how these choices were motivated by the resource. Bockstael and McConnell [1993] have noted the process of developing monetary measures of economic value requires the indirect methods to define two linked exchanges that compose each choice - one in an observable private good and one in the linked non-market environmental resource. We use the former (the private good) to reconstruct the implicit terms for the latter. The assumptions required for the Hicksian measures of the value can be described as establishing a correspondence between the Marshallian representation of the circumstances of the choice and measure of consumer surplus for the private good and the corresponding terms and surplus measure for the environmental resource.[12]

Table 1 summarizes the information usually available, the information the analyst adds, and the link to the WTP model for each of the three indirect methods -- travel cost, hedonic property value (and wage), and averting behavior (household production)

models. The last two columns in the table define the form of the function usually estimated, its relationship to conventional Marshallian measures for behavior (through indirect utility function), and the connection to the willingness to pay function defined in equation (2). To use these choices to reconstruct measures of the monetary values requires enough information to isolate the WTP function. The first term in each of the expressions in the last column of Table 1 is usually observed. Assumptions about the other intermediate connections must be introduced to complete the connections. In the case of the travel cost model, for example, it is the demand function for trips to a recreation site. In this case, the objective is often to estimate the economic value of one of the site's characteristics such as water quality.

The restrictions to the WTP function implied by an assumption of weak complementarity between $x_i$ and $q$ provide one such example. In this case when $\frac{\partial WTP}{\partial q}$ is evaluated, at a price where $x_i = 0$ (the choke price), weak complementarity implies that the marginal WTP is zero. To interpret the specific implications of this result for Table 1, recall that equations (1) and (2) relate to the WTP for an improvement in $q$. If we considered the WTP for another type of change, say in the access conditions to a recreation site, the links would be different.[13] Moreover, if we impose a different relationship between the private good and $q$, the nature of what can be learned about the WTP function from observed behavior changes. Prior restrictions are thus important, but they do not escape the fundamental dependency of these approaches on information about some type of choice.

C. Indirect Methods - Implementation and Performance

1. Travel Cost

Two types of data have been instrumental in travel cost recreation demand studies. The early literature generally used aggregate origin zone data, where trips to a specific site from a given location (usually a county, but sometimes a distance or "origin" zone, as envisioned in the original Hotelling [1947] letter) are related to round-trip distance (or distance scaled by a constant per mile cost factor). The trip is assumed to measure the quantity of the resource "used" and who often measured relative to the population of the zone. Economic and demographic characteristics of the populations in each origin zone, as well as some substitution indexes for other recreation sites were "attached" to each observation (as if they were relevant for the representative user in each zone). These data provide the basis for estimating site demand functions, both as individual demand equations and in systems of demand functions. While these early applications were "successful" in developing plausible estimates for the price and income elasticities, they were also subject to concerns about using aggregate data under the mantel of a "representative agent" argument.[14]

Individual records of recreational behavior provide the second type of data. A record of problems with these data due to poor sampling procedures, infrequent consumption (of recreation trips), as well as the inherent complexity of the economic decisions involved, have made these applications a "fertile" ground for advancing micro-econometric methods. Initially borrowing from insights already developed in the models used in labor economics and modal choice decisions (for transportation applications), recreation applications are now leading other applications in their recognition of the

important interaction between micro-theory and econometrics.[15] It is impossible to describe completely the full range of economic and econometric issues currently being discussed in this active literature. Instead, I have selected a few areas where research seems especially active.

Substitution and nonparticipation have been dominant concerns of the literature to date. Records of individual behavior have usually been collected from on-site (which implies the surveys don't observe non users and may over represent active users) or from surveys of user groups identified through licenses, boat ownership, or some other eligibility criterion. Both surveys generally ask about recreation trips in a recent time period. For the former that period usually includes the current trip so the quantity measure is a truncated random variable (at one). For the later, we do not learn how the state of environmental resources or the conditions of access influence people's decisions become part of the sampled population (i.e., purchase a license, a boat, etc.).

Both types of surveys have had difficulty in either collecting information about substitutes or, when it has been collected, they have experienced empirical problems in incorporating substitutes' price and quality information into the analysis (see Smith [1989]).

In my opinion, most recreation economists, if polled, would likely identify some type of random utility model (RUM) as the preferred modeling strategy because it allows the effects of multiple sites (with different attributes) to be incorporated in a way that permits benefit measurement. Because of this judgment, this sub-section considers some active research with the RUM approach.

The initial RUM applications focused on a single trip occasion and the selection of a recreation site for that trip. Each such decision was viewed as independent of other decisions. Preferences were described by a random, indirect utility function that hypothesized each individual would select the best site and then, conditional on that choice, make other allocation decisions (i.e., $v(p,q,m) = Max\left[V_i(p_i,q_i,m) i = 1,2,\ldots n\right]$, where $p$ and $q$ are assumed to be vectors that include the arguments $p_i$ and $q_i$, $i$ = *1 to n*, with $i$ indexing the recreation sites). Each conditional indirect utility function, $V_i$, is assumed to include an independent random error. This specification recognizes that we cannot describe people's recreation site choices perfectly. As a rule, the noise in the process is assumed to arise from the analyst's perspective. Usually (but not always), recreationists are assumed to know what they will do. This distinction is important because it affects the interpretation given to benefit measures from this model.

Selecting a Gumbel distribution allows a closed form solution for the expression describing the probability any particular site(s) would be selected as in equation (3):[16]

$$Prob(Max(V_1,\ldots,V_n)=V_s) = \frac{\exp(\tilde{V}_s)}{\sum_j \exp(\tilde{V}_j)} \qquad (3)$$

where $\tilde{V}_j$ is the nonstochastic component of $V_j$ ($i.e., V_j = \tilde{V}_j + \varepsilon_j$)

and this specification assumes $\varepsilon_j$ an independent Gumbel error distribution follows.

From this basic form, the literature has considered a number of implementation and modeling questions, including the following issues:

- Because the simple RUM implies independence of irrelevant alternatives (IIA), nested models have been proposed as alternatives. In these specifications the Gumbel is replaced with a generalized extreme value distribution (McFadden [1974]). Models derived from this general structure consider an individual's choices in a sequence. For example, in Kaoru's [1995] model for sport fishing an individual is assumed to select a number of days for his (or her) fishing trip, then a region of the North Carolina coast, and then within the selected region a specific site. By sequencing the choices, the model restricts the nature of the substitution relationships among alternatives. A similar type of logic has been used in modeling substitution in the specification of preference or production functions with nested subfunctions. By separating commodities into specific sub-functions, these approaches control gross and net substitution elasticities and therefore the interrelationships among the commodities. The generalized extreme value function resembles a nested set of CES (constant elasticity of substitution) functions and constrains the substitution relationship among alternatives in an individual's choice set. Of course, they require some basis for developing the nesting structure and have been found to be sensitive to that structure as well as to the conditions required for the model to be consistent with constrained utility maximization (see Kaoru [1995], Kling and Thompson [1996] and Herriges and Kling [1995]).
- The simple model's single trip orientation has led to efforts to expand the structure to repeated choice and sequential choice models, as well as to allow for the possibility

of no trip being taken (see Morey, Shaw and Rowe [1991], Morey, Rowe, and Watson [1993] and Parsons [1991]). Comparisons of the models using actual data sets imply highly variable benefit measures relative to conventional RUM formulations (see Liu [1995], Kling and Thompson [1996]).

- The definition of the choice set and the specification of what is a site (especially when there is the possibility to aggregate across alternatives) have been found to be important influences on the benefit measures derived from RUM analyses (see Kaoru, Smith, and Liu [1995], Parsons and Kealy [1992], Parsons and Needelman [1992], Feathers [1995] and Parsons and Hauber [1996]).
- Developing seasonal measures of use and willingness to pay requires that either the RUM framework be specified in a way that links choices over time or that applications of the model for trip occasions be consistently related to the more conventional travel cost demand models that describe all trips taken in a season. Current discussion of this logic by Parsons and Kealy [1996], Feather et al. [1995], Hausman et al. [1995], and Shonkwiler and Shaw [1996] have proposed, with varying levels of completeness, analytical descriptions of price and quantity index numbers derived from the models of site choice probabilities. The full implications of alternative definitions for the role of the time constraints in the definition of travel cost measures for these approaches have not been developed.[17]

Despite the fact that estimates of benefits from all versions of the RUM framework appear quite sensitive to strategic modeling decisions, enthusiasm remains high for continuing to base policy analyses on some type of RUM. The framework is attractive to practitioners because it consistently incorporates diverse sources of

heterogeneous site characteristics. These characteristics provide the primary means to describe the status of the environmental resources supporting recreation uses. For example, in the case of recreational fishing, historic catch rates, emission loadings, contamination notices, as well as other proxy variables have served as the indicators of the quality of specific lakes, rivers, or areas along the coast that support this recreation. These would be difficult to include within standard travel cost demand models. Unlike cases where market prices are available, we cannot use some form of equilibrium condition linking prices of heterogeneous goods, such as the one underlying the hedonic price function, to estimate the marginal values of these features.[18]

One explanation for the sensitivity of the available results from these models to their assumptions is that considering the data generally available and the requirements for the valuation measures, it is clear that substantial prior information must be added to the models. These judgments about: the functional forms assumed to characterize individual preferences, time horizons for choices, the assumed choice sequence (i.e., nesting), etc. Indeed, even in situations where extensive diaries can be assembled, there are limits to the details that can be reliably assembled. The only way to compensate for these informational limitations is to seek alternative sources of valuation information for the same resources.

This suggestion is not simply advocating "more and better data". Rather, my suggestion has more a practical goal. Travel cost demand models are developed to estimate use values for recreation sites or for characteristics of these sites. Given this goal, it seems reasonable to examine the potential for using other tradeoffs involving the same sites or quality characteristics. It may be possible to use these related decisions

jointly with models applied to trip taking decisions in estimating the required values. By considering the other ways people adjust to the constraints it may be possible to isolate other substitutions that reveal the marginal value. The travel cost model relies on one type of tradeoff involving the travel expenses and time required to acquire the services of recreational resources. People make others that have not been pursued in as much detail. For example, both fresh and sport fishing recreationists use boats. To the extent they purchase the boats (and subsequently maintain or upgrade them), these decisions can be expected to be influenced by the available recreational resources.[19] By maintaining a structural link (such as weak complementarity or perfect substitution) between the observable private good decisions and the environmental resource, it should be possible to recover from these decisions a measure of the economic value (due to use) of changes in the environmental resource even if they are made infrequently.[20]

My proposal is not simply for joint estimation, but calibrated assessments.[21] That is, consider using the valuation estimates from different tradeoffs involving the same non-market resources with separate private goods to evaluate the benefit estimates implied by the RUM framework. To date these strategies have been confined to linking travel cost and contingent valuation data (Cameron [1992]), or to the early efforts to evaluate contingent valuation estimates (see Brookshire et al. [1982]). In Cameron's application both measures must be available for each individual. What is proposed here does not require this type of data because the objectives are more modest. Simple comparisons may help discriminate among the modeling assumptions.

A second type of composite strategy would exploit micro and aggregate data for the same recreational sites. Anderson, De Palma, and Thisse [1988, 1992] have

developed links between the simple RUM framework (expressed in terms of linear indirect utility functions) and demand functions for a representative individual. They have also shown the relationship for a constant elasticity of substitution specification for the representative consumer. This case directly links to a linear in the logarithms (of price and income) indirect utility specification for a simple RUM. More recently Verboven [1996] has established the relationship for the case of the nested logit with linear indirect utility and as well as the group constant elasticity of substitution utility specification for the representative agent's preferences.

These results permit consistent estimates of travel cost demand models based on aggregate, origin zone data (that relies on a representative agent model) to be connected to the results from RUM models developed with micro data. It is possible to calibrate findings from aggregate models to estimates based on surveys of users at the same sites.[22]

## 2. Hedonic Price Models

Hedonic price functions seem to provide one of the oldest and most durable of economists' methods for measuring consumers' responses to quality differentials. Waugh [1929] first used them to adjust prices for differences in the attributes of fresh vegetables. Tinbergen [1956] and Roy [1950] demonstrated that the framework described the conditions for equilibrium in the labor market with heterogeneous people and jobs. Applications for valuing air quality trace their origins to Ridker and Henning [1967]. Using Table 1, the hedonic price function offers the most direct approach

(largely free of specific assumptions about preferences) for measuring the marginal value of amenities (see Rosen [1974]). The equilibrium condition implies that the marginal price will measure the marginal rate of substitution between q and a numeraire good.

For the case of air pollution, the experience of numerous studies since Ridker and Henning confirms a significant negative relationship between air pollution and property values that holds over a wide range of conditions (Smith and Huang [1993,1995]). Unfortunately the recent research record ends largely with this finding of support. To my knowledge, no study has successfully estimated the WTP function as a second stage model derived from the hedonic price functions. Zabel and Kiel's study [1994] provides the most recent attempt to implement a hedonic framework in a consistent way with measures of air pollution for multiple cities. They use a panel data framework to control for house and neighborhood effects and focus on changes in air quality and their effects on changes in housing prices. The results yield both positive and negative estimates of air pollution's influence on property values. They do not support work on a second stage model for the panel data base. Given the current understanding of the complexity of recovering estimates of the marginal WTP function from hedonic estimates (see Bartik [1987], Epple [1987], McConnell and Phipps [1987], Palmquist [1991], all of the original attempts to estimate the second stage models would not meet conditions for identification. Moreover they do not have the micro detail required to link the estimated marginal WTP to the economic and demographic characteristics of the households who purchased (or rented) the houses involved.

The primary focus of new research in this area has been on two issues. The first might be described as "speciality" site-specific disamenities such as hazardous waste

sites (Michaels and Smith [1990], Kolhase [1991], Kiel [1995]), incinerators (Kiel and McClain [1995], odor due to private residences' proximity to hog farms (Palmquist et al. [forthcoming], shoreline erosion (Kriesel et al. [1993] and Van De Verg and Lent [1994]), and others. The second uses the Rosen [1979] - Roback [1982] arguments for links between property value and wage markets to propose joint estimation of the marginal willingness to pay. A key application of the resulting estimates (suggested by Rosen [1979]) has used to use them to develop quality of life measures for locations.

Equation (4) reports an expression comparable to what is used to describe the proper "joint market" analysis required to estimate the marginal value for a site-specific amenity ($q_k$):

$$\frac{\partial WTP}{\partial q_k} = \frac{\partial r}{\partial q_k} - \theta_k \frac{\partial w}{\partial q_k} \qquad (4)$$

where:

$r$ = the land rent

$w$ = wage rate under same time horizon as the land rent

$\theta_k$ = a measure of exposure to amenity $q_k$ at the job

(i.e., wage related measure, $q_k^w$, is linked to $q_k$ *as* $q_k^w = \theta_k \cdot q_k$ )

Quality of life (*QOL*) indexes are derived from the marginal WTP as a simple composite of the site specific amenities as in equation (5):

$$QOL_i = \sum_j \frac{\partial WTP}{\partial q_j} \cdot q_{ji} \qquad (5)$$

This formulation holds the function computing marginal WTP for each site specific attribute constant across locations assuming a cross city equilibrium as in Blomquist et al. [1988]). Land rents are positively affected by desirable amenities (i.e. $\partial r/\partial q_k > 0$ if $q_k$ is desirable and wages are negatively impacted (i.e. $\partial w/\partial q_k < 0$) so their contributions in equation (4) are both positive (after adjusting for the sign in the wage equation).

There are any number of difficulties that one could raise with the Rosen-Roback structure. The specific equilibrium result follows from the assumption that residential location and job are changed simultaneously when an individual adjusts location to improve site specific amenities. This ignores the basic idea that households also move within larger communities to improve housing and site related amenities. This was the original formulation and test of the Tiebout [1956] model (see Oates [1969]). Such changes do not require job changes. How does the marginal household evaluate its choices to obtain site related amenities (and to avoid the disamenities)? It is not clear that the "site/job story" is necessary.

To implement their framework we must have comparable data for both housing (i.e., land rents) and wages across cities. There is considerable evidence suggesting the existence sub-markets for housing within a single large city, so the assumption that a national housing market determines site amenities seems untenable.[23] The same comment, though with less clear-cut evidence, applies to labor markets and the wage hedonic equation.[24]

If we accept the prospects for different adjustment processes, this does not invalidate the concept of a quality of life index. It does lead to questions about a single set of weights across sites and the substitution of estimates for $\partial w/\partial q_j$ from a framework

like the one used in labor economics to investigate the structure of wages into equation (4).

More generally, several research issues do follow from this line of research. First, we might consider *QOL* as a welfare index (Diewert [1993]). This would require considering a more traditional approach for defining index numbers for *QOL* measures based on the level of the Hicksian expenditure function rather than a simple first order approximation. The resulting $\tilde{QOL}_i$ would then be consistent with the welfare theoretic interpretation of price indexes as in (6):

$$\tilde{QOL}_i = \frac{e(p_i, q_{1i}, \ldots., q_{Ki}, \bar{u})}{e(p_N, q_{1N}, \ldots., q_{KN}, \bar{u})} \qquad (6)$$

where the subscript N identifies a reference site N

It is worth noting that *e(.)* could be interpreted as a partial expenditure function (i.e., in terms of exogenous income required to realize a given utility level, recognizing people make commodity as well as labor/leisure choices with given prices and wage rates as in Just et al. [1982]. In this case local wage rates would be included as one of the determinants of *e(.)* if the joint supply site/job model is not used). The importance of this distinction is that we don't escape the task of distinguishing the marginal willingness to pay function from the composite of marginal price relationships describing equilibria in housing and labor markets. To isolate the marginal WTP requires that there be sufficient information to separate preference from supply influences in the joint determinant of the equilibrium. That is, consistency in both *QOL* indexes and benefit measures requires that we go beyond the estimates of marginal WTP at a single equilibrium.

A second issue that follows from considering other approaches households might select to adjust to disamenities associated with their residences. Following the basic logic I used to begin this discussion (i.e., that indirect methods hunt for substitution and complementarity relationships with other private goods to construct monetary measures of the economic value of non-market goods), we might consider how these other types of adjustments influence the interpretation of the hedonic price equation. The opportunities for substituting related resources should influence the tradeoffs we observe in markets. This offers an explanation for Clark and Kahn's [1989] decision to include a wide range of recreational resources at some distance from a household's residential location as sources of compensating differentials in their wage models. It does not tell how to determine the geographic extent or character of the resources that serve as substitutes for one available as the site specific amenity.

There are two aspects of the Rosen-Roback analysis that should be distinguished. The first concerns the ways households adjust to site specific amenities. It is central to most indirect methods for nonmarket valuation. The criticism raised with this dimension of the Rosen-Roback framework is that households are assumed to make simultaneous housing and job decisions. While we can acknowledge that there may be multiple opportunities for adjustment, this does not mean they are relevant to <u>all</u> individuals. Requiring that all would meet Rosen and Roback's proposed link would seem implausible. Indeed, existing literature suggests that it is possible to use the heterogeneity in individual circumstances to test aspects of the model. For example, retired households should not be influenced by the wage effects, and have the opportunity to realize site-specific amenities without experiencing the wage reductions. Graves and

Waldman [1991] developed such an analysis and found direct support for a focus exclusively on housing market conditions for these types of households.

Equally important those whose jobs require frequent travel to locations with considerable access to amenities (e.g. airline pilots, traveling sales personnel, telecommuters, etc.) may select residences to economize on site rents. Other individuals with travel routes that do not provide the amenities or the time to enjoy them will consider the residential amenities where they live and can do so free from the lower wages paid by "local" employers. Of course, these hypotheses rely on these types of individuals' wages being set independent of site specific amenities. More generally, migration behavior should be linked to the same factors affecting equilibria in the housing and labor markets and may offer opportunities for the types of calibrating evaluations discussed in the sub-section on travel cost demand models.

The second aspect of the Rosen-Roback model concerns the determination of equilibrium prices in housing and wage markets. If their description offers a reasonable approximation, then we would expect the equilibrium prices and wages to be jointly determined. This can be expected to compound the complexity of identifying marginal willingness to pay functions from the information available in the marginal price and wage functions.

3. Averting Behavior Models

Models to describe averting or mitigating behavior can be developed using a household production framework that postulates a set of activities households can adopt to improve the amenities they experience. At one level, the hedonic model could be considered as one such adjustment -- moving to change amenities. For the most part,

these averting approaches envisioned in these models are not as "drastic" and usually involve smaller resource or time re-allocations. Ridker's [1967] original proposal suggested that the soiling effects of air pollution would require increased household cleaning activities to maintain the same level of cleanliness. We could also think of air conditioning homes and cars to avoid air pollution, water filters or public water supplies as responses to avoid contamination of private sources of water, and other types of adjustments as examples (see Harrington and Portney [1987]).

To link the observed changes in expenditures or activities to Hicksian welfare measures requires further assumptions. Perfect substitution was recognized by Freeman [1979] as the assumption underlying Ridker's proposal. Subsequent work by Mäler [1985] and Smith [1991] formalized the link to household production and the assumptions required to assure expenditure changes will in fact measure willingness to pay for the desired amenity.

As a rule, empirical applications have demonstrated the plausibility of the hypothesized links (Smith and Desvousges [1986b], Jakus [1994], Abdalla et al. [1992]), but not the fully defined valuation measures. Some recent developments may increase interest in the method. The first of these involves empirical models proposed by McConnell, Strand, and Blake-Hedges, [1991] to explain the catch on sport fishing trips. In a subsequent application we (Smith, Liu and Palmquist [1993]) interpreted these models as providing direct estimates of the household production technology for sport fishing, given total catch can be assumed to provide a plausible output measure. Similar interpretations could be proposed to describe the yields of other consumptive recreational activities. To the extent the resulting output is related to externalities (nutrient and

pesticides loadings into the coastal areas used for fishing), it is possible to meet the theoretical requirements for consistent benefit measurement.

Building on an early proposal by Shapiro and Smith [1981], Robert Horst of Math-Tech [1982] developed measures of the effects of air pollution on household expenditures. This analysis could be interpreted as an attempt to use household budget information to estimate the "input demands" for a household production technology. By adapting Pollak and Wales' [1981] proposal for translating parameters for pollution in linear expenditure models (their suggestion was for demographic effects), he linked household expenditures, as mitigating responses, to the local concentrations of air pollutants. Subsequent work by Gilbert [1985] extended the approach to consider how these adjustments in expenditures could be related to estimates from hedonic property value models.

In a more recent application of this logic Liu and I [1996] have proposed using expenditures on a sport fishing trip with this framework as an alternative to a RUM for valuing site quality. The analysis interprets the expenditure categories as reflecting inputs to a household production function. By using the translating parameters we adopt a model consistent with the Horst-Gilbert proposals. It is also one that implicitly maintains an assumption of "generalized" perfect substitution for the goods linked to the characteristics of site quality.

Finally, it is important to recognize two other ways the averting behavior framework has affected the current practice of non-market valuation. The first of these arises in the development of models to estimate an individual's valuation for risk reductions. The consumer response approaches to estimating the statistical value of a

life[25] or the values implied by decisions to wear seat belts, purchase smoke alarms, or adjust in other ways to reduce risk implicitly impose a perfect substitution assumption between the behavior and the perceived reduction in risk. This follows from a simple description of the expected utility, *EU*, (without altruism toward one's heirs) to describe this behavior. Let $\pi$ designate the probability of survival and *v(m)* the indirect utility associated with "life" (recall *m* is income, and for this example *p* and *q* are treated as constants and dropped from the expression). $\pi$ is assumed to be a linear function of the averting response ($\pi = a + b \cdot x$). This implies equation (7) describes the individual's behavior:

$$EU = (a + bx) \cdot v(m) \qquad (7)$$

The Hicksian marginal willingness to pay for risk reductions is measured by the incremental expenditures on the private good ($x$), offering a means to reduce the risk of dying. Thus, the arguments used in this setting to value risk can be directly related to the theory underlying valuation of environmental amenities.

The second line of influence is the framing of contingent valuation (CV) questions. Increasingly, the CV literature has described the proposed changes in environmental resource offered to survey respondents using a specific plan that could lead to the proposed changes. The Carson et al. [1992] effort to estimate the monetary loss people experienced due to the Exxon Valdez oil spill used a plan to prevent future injuries from oil spills in this area instead of the specific injuries. The proposed plan can be considered as a type of public averting (or mitigating) behavior. This analogy highlights the implicit role of perfect substitution in framing CV surveys.

D. Direct Methods

1. Context

Contingent valuation seems deceptively simple -- just ask people what a specific hypothetical resource change is worth to them and assume they will answer the question in exactly the terms it was asked. The standard response of CV skeptics is that "hypothetical questions yield hypothetical answers." The key word in this description and critique is hypothetical and the success CV has experienced in a large number of applications relates directly to the effort expended at the design stage of the CV survey to present choices that people feel are real. Unfortunately, there are no simple steps that will guarantee a survey question will be perceived by respondents as real. The present state-of-the-art recommends a mix of focus groups, cognitive interviews, and pretests to evaluate whether the set of information, visual aids, and circumstances framing the CV questions are being interpreted by most respondents the way the investigator intended.

Recently contingent valuation questions and descriptions have been described as the object of choice and the proposed circumstances of choice (see Carson et al. [1994]). This terminology avoids using a commodity orientation and instead recognizes that what is presented in most CV applications is a proposed plan to alter some environmental resource (or set of resources).

I believe this distinction is important. Use of stated preference methods for private goods or services (as in applications in marketing and transportation, see Louivere [1996b]) can rely on respondents believing the plausibility of having a new type of orange juice, a new train route (or schedule), or some variation in the characteristics of

currently available goods and services. People do not have similar direct choices available for environmental resources.[26] When people are unable to select an "amount" for the environmental resource consumed, a CV question that allows some change is constructing a new choice. Respondents' decisions permit measures of economic value to be constructed. It is possible to use the analogy between "CV-plans" and averting behavior to suggest a direct relationship between stated choices and Hicksian WTP.

## 2. A Simple Framework for Describing CV Questions

To simplify the algebra, assume preferences can be described with a CES (constant elasticity of substitution) preference function with one composite private good, with price $p_1$, a private rationed commodity, $x$, that serves as perfect substitute for the nonmarket environmental resource, and the resource, $q$, (retaining the earlier notation). Contingent valuation offers a plan to alter $q$. Here I treat this plan as a change in the amount of an existing the private rationed good, $x$. In the framework I assume that $x$ is fixed and each respondent has paid $c(x)$ for it. The framework is not affected by assuming there is a fixed price per unit. It is important to require that the plan is the only way $x$ can change. Thus, people may recognize that they are paying for the initial amount of $x$ (e.g., people do recognize that taxes pay for public services, but may well have little conception of the unit cost of these services). Alternatively, they may not. What is important is that they have no means available to alter either $x$ or $q$. Assume the objective is to measure the WTP for a change from $q_0$ to $q_1$. This is given in equation (8).

$$WTP \quad = \quad m - c(\bar{x}) - p_1 \left( \left( \frac{p_1}{m - c(\bar{x})} \right)^{\alpha} + (\bar{x} + bq_0)^{\alpha} - (\bar{x} + bq_1)^{\alpha} \right)^{-\frac{1}{\alpha}} \qquad (8)$$

$c(\bar{x})$ is the perceived cost for a specific amount of the rationed good, $\bar{x}$, and the indirect utility function is given by $v = \left( \left( \frac{p_1}{m - c(\bar{x})} \right)^{\alpha} + (\bar{x} + bq)^{\alpha} \right)^{\frac{1}{\alpha}}$.

The challenge with framing a CV question is to identify a plan that offers some change in *x* which is perceived to be a perfect substitute for *q* and to be assured respondents interpret the proposed financial consequence of the choice is as an addition to the existing costs of their initial holdings of *x*, designated here as $\bar{x}$ and $c(\bar{x})$ (for the costs). To illustrate how this comparison helps explain responses to CV questions consider an offer of an addition of $\Delta x$ to $\bar{x}$ at a total cost of *t* in comparison with direct changes in *q*. The threshold value of *t*, *t**, defining the willingness to pay for $\Delta x$ is:

$$t^* = m - c(\bar{x}) - p_1 \left( \left( \frac{p_1}{m - c(\bar{x})} \right)^{\alpha} + (\bar{x} + bq_0)^{\alpha} - (\bar{x} + \Delta x + bq_0)^{\alpha} \right)^{-\frac{1}{\alpha}} \qquad (9)$$

To have *t** = WTP for $(q_1 - q_0)$ $\Delta x$ must be perceived as equal to $b(q_1 - q_0)$. The specification $x + bq$ implies perfect substitution. Mäler has demonstrated *q* need not enter in a linear form. It could be replaced by a function of *q*, *h(q)*. This change means that the link between *x* and *q* can change as the "amount" of *q* comprising each individual's baseline condition changes. Actually, Mäler's generalization implies that perfect substitution can be imposed for measures of *q* that might be different from observable technical measures. $h(q)$ can represent how an individual perceives the amount of the environmental resource. Thus, we are not required to use the number of acres of a wilderness area or the size of a population of wildlife as the "correct" measure

of individual perceptions of the amount of environmental resource contributing to well-being. Moreover, descriptions of plans to realize changes in $q$ may need to be changed with the size of the baseline or the plan. They may differ across individuals. Thus, the development stage of a CV questionnaire can be viewed as a process attempting to find a framing that communicates in comparable terms to most respondents.

We can also use this framework to consider the consequences of imperfect perceived substitution between the changes described by the plan and the intended change in the environmental resource. This can be considered by replacing $\bar{x} + h(q)$ in the specified indirect utility function with a CES subfunction, say $(\bar{x}^{\beta} + (h(q))^{\beta})^{\frac{1}{\beta}}$. As we change the assumed degree of substitution it is straightforward to demonstrate that the WTP for changes in *x* provide a lower bound estimate for the WTP associated with $(q_1 - q_0)$.[27]

3. Current Evidence on the Reliability of CV

Most questions about the reliability of CV arise either because the choices stated in response to these survey questions do not have realized financial consequences or because they may be distorted by the strategic incentives (i.e., respondents who believe they will in fact pay understate their WTP, while those who do not and want what is offered will overstate their values).

There is no unambiguous way to resolve either question -- any more than there is a means to fully validate the maintained assumptions underlying the indirect approaches to nonmarket valuation. Several methods have been used to gauge their importance. I will summarize what I believe has been learned from two of the approaches used for

evaluation -- simulated markets studies and reliability "tests" for CV results based on conditions implied by the economic theory underlying WTP functions.

Following the pioneering work of Bishop and Heberlein [1979] a variety of studies have compared the outcomes in simulated markets for private goods with the results derived from CV surveys. These studies can never directly address applications where CV will provide the only means to estimate monetary benefits.[28] This conclusion follows because a financial consequence can be enforced (in the simulated market) only when it is possible to exclude those who do not pay.

Based on applications to date, it appears the specific details defining each simulated market's rules for transactions can be important to comparisons made with CV choices. Adjusting for these details, it would appear the conclusions derived from the research to date depend on the "eyes of the beholder". To understand what I mean, consider five examples -- three with private and two with public goods. Dickie, Fisher and Gerking [1987] sold strawberries as actual transactions and as stated purchases. After accounting for one enthusiastic team of "sellers", they concluded that there was agreement in the two data sets' descriptions of individual preferences. By contrast, Hausman and Leonard [1992], analyzing the same data, argue there is a strong case for disparities and significant differences in the consumer surplus estimates implied by the simulated and actual sales.[29] My own analysis of these data (see Smith [1994]) suggested that both samples are small (72 observations) and the estimates are sensitive to the specification used for the demand functions. As a result, I concluded (given the inherent variability in demand models for any private product) there was not a basis for suggesting the two samples were derived from different behavioral processes. [30]

Cummings et. al. [1995] reports three comparisons for juices, solar calculators, and chocolate candies. In all three cases they report significant and fairly striking differences in the proportion purchasing each product for the samples involved in actual sales in comparison to the stated purchases (juicer - 41% versus 11%; calculator - 21% versus 8%; chocolates - 42% versus 8%). Only one of these comparisons varied the price proposed for take-it or leave-it sales (i.e., the one involving solar calculators). When I analyzed the sample including cases with different prices for the calculator experiment I found none of the choices (actual or stated) were influenced by the stated price (Smith [1994]). If one considers the comparison using the same sample as Cummings et al., and exclude those who currently own calculators, there was no significant difference in the proportions purchasing or stating an intention to purchase the calculator.[31]

The third application involves a recent experiment Carol Mansfield and I recently conducted within a willingness to accept (WTA) framework (see Smith and Mansfield [1996]). Using a sample of over 500 respondents who had completed a telephone-mail-telephone (TMT) survey we split the sample into two groups and attempt to recruit them into a follow-up survey for a new undefined issue involving the same type of TMT framework. Half of the sample were given real offers ranging from $5 to $50 for their participation in a new survey. The other half were told there was a plan to develop such a group and asked if it was possible to make this offer what would they decide. Our findings suggest there are no differences in the two groups choices. This finding was quite robust, being confirmed using Chi-Square tests for the two groups choices (with 83.1% accepting in the real offer and 81.7% in the hypothetical) as well as in likelihood ratio tests for choice functions estimated based on the decisions. Using the pooled

sample the amount offered, household income and a number of other variables were statistically significant and plausible determinants of respondents' decisions. While it is important to acknowledge that a WTA framework implies a quite different financial consequences than as WTP format, the record prior to our study would argue that a close correspondence between stated and actual choices would be equally difficult to realize in this case.

The last two examples involve objects of choice that have some public good characteristics (i.e., people cannot be excluded from enjoying the resource if it is provided, even though they did not pay). An important implication of this characteristic arises with a change in how the payment mechanism is described. For both the actual and stated responses, it is described as a donation, not a price! This may well change the perceived incentives. Nonetheless, for the case of increasing water flows to promote the habitat for a significant trout fishing area, Duffield and Patterson [1992] find consistency that is sensitive to how the differential rate of non-response is treated for the actual solicitation versus the CV surveys.[32] When all non-respondents are treated as having zero values there are significant differences between the estimated means for actual and stated valuations.

Brown et al. [1996] considers a similar situation -- contributions to return a hard soil road to natural conditions on the North Rim of the Grand Canyon. Respondents were told that volunteers convert the road but that there were additional costs of about $640 per mile to restore it from dirt road to natural conditions. Discrete take-it or leave-it questions for stated amounts and open-ended questions were asked of independent sets of respondents requesting actual contributions and stated contributions. In the CV cases

(both the discrete and the open-ended) the study informed respondents that they "will not actually be asked to pay for the project."

The results suggest significant differences in choices for all but one stated contribution level between actual and CV responses to the discrete (take-it or leave-it) choice format and significant differences in the estimated WTP for both the open ended and discrete choice questions. The later displayed larger differences with the ratio of stated to actual of 6.45 versus 4.11 with the open ended. While this evidence would seem decisive, it is also consistent with my initial comments about CV -- the questions must strive to convince the respondent what is being asked is comparable to a real choice. That is, we do not know how much of the difference between actual and stated choices (and payments) is due to the assurances given to the CV respondents that no payments would be made.

The second set of research on the reliability of CV estimates has proposed "tests". This approach recommends that reliability be judged based on the practices used in conducting the survey and the properties displayed by the CV estimates of WTP. An important stimulus to this research was the recommendations of the National Oceanic and Atmospheric Administration's (NOAA) Panel on contingent valuation (see Arrow et al. [1993]). Co-chaired by two Nobel laureates, Kenneth Arrow and Robert Solow, the Panel's report provides a set of guidelines for CV surveys that include recommendations for survey development activities, administration, and analysis. A subset of the items identified in their guidelines were given special emphasis and described as burden of proof requirements. They are described s follows:

> "if a CV survey suffered from any of the following maladies, we would judge its findings 'unreliable':
>
> - a high nonresponse rate to the entire survey or to the valuation question
> - inadequate responsiveness to the scope of the environmental insult
> - lack of understanding of the task by the respondents
> - lack of belief in the full restoration scenario
> - 'yes' or 'no' votes on the hypothetical referendums that are not followed up or explained by making reference to the cost and/or the value of the program" (Arrow et al. [1993] p. 4609)

Provided their guidelines were used and the burden of proof requirements met, the Arrow-Solow Panel concluded by noting:

> . . . under those conditions (and others specified above), CV studies convey useful information. We think it is fair to describe such information as reliable by the standards that seem to be implicit in similar contexts like market analysis for new and innovative products and the assessment of other damages normally allowed in court proceedings.
>
> . . . CV [contingent valuation] produces estimates reliable enough to be the starting point of a judicial process of damage assessment, including passive-use values [i.e., nonuse values]. (Arrow et al. [1993] p. 4610, with bracket terms added).

Following the logic of this report, four characteristics have been identified by different authors (I have attempted to identify the primary source(s) of the proposal in parentheses

after each item) important to any judgment about CV estimates provide reliable measures of economic values:

(1) CV choices should be responsive to the scope (or amount) of the object of choice offered to respondents (NOAA Panel).[33]

(2) CV choices should pass construct validity tests, indicating that they are related to a set of economic variables hypothesized to be important in actual choices. These variables include: the cost or financial consequence proposed to respondents; other measures of the terms of availability if they are relevant to access to what is offered; the individual (or household) income, depending on how the choice is offered); factors related to the quality of the object offered; measures of the availability of substitutes; and, to a somewhat lesser degree, taste related demographic variables and measures of individual attitudes that are consistent with preferences for the object of choice. (Mitchell and Carson [1989] and NOAA Panel).

(3) WTP estimates derived from CV surveys should be consistent with the "adding-up" condition. That is, a proposed change in $q$, divided into components and presented as a sequence should yield separate WTP estimates when added together are approximately equal to the WTP for the full change in $q$, except for what are usually small income effects (Diamond and Hausman [1993], Diamond [1996]).

(4) CV choices and their implied WTP estimates for objects, that can generally be argued to have different "importance" to the "typical" individuals, should be significantly different. (Kahneman and Ritov [1994]).

Not all economists would agree with these as reliability "tests". Moreover, recently Diamond [1996], using the Desvousges et al. [1993] bird loss example, has suggested that the scope test can be made more specific -- with a bound on the WTP estimates for two different sized objects of choice (designated here by $\Delta q_1$ *and* $\Delta q_2$, with $\Delta q_1 > \Delta q_2$). For example we could treat $\Delta q_1$ as 100,000 birds lost and $\Delta q_2$ as 1,000 birds lost from a given overall population of birds. The WTP's would refer to avoiding these losses. Diamond's bound for such a case is given in equation (10):

$$WTP(\Delta q_1) \quad \geq \quad (\Delta q_1 / \Delta q_2) \quad \cdot \quad WTP(\Delta q_2) \qquad (10)$$

This result follows from three assumptions: (a) $\triangle q_1$ and $\triangle q_2$ represent losses in a base level of $q$ to be avoided; (b) the utility function is quasi-linear, so the marginal utility of income is constant; and (c) the plan described as providing the means to avoid the losses is perceived to provide outcomes that are perfect substitutes for the environmental resource $q$. The first two assumptions influence the specific form of the WTP function and, as Diamond has argued, seem plausible as descriptions of a number of CV applications. The last is not as plausible and plays a central role in Diamond's specific bound for responsiveness to scope as well as in the Diamond and Hausman adding-up test.

The Hicksian WTP measures differences in the "spacing" of indifference curves (measured in terms of a numeraire good and the nonmarketed resource) in monetary terms. This can be appreciated when the WTP to obtain the change is written as equation (11), (i.e., with the initial income $m_0$, an unchanged price vector, and improved $q_1$, a

higher utility level, $u_1$ can be realized). this equation leads to the informal characterization of WTP as a monetization of the change in utility from $u_0$ to $u_1$.

$$WTP = e(p, q_1, u_1) - e(p, q_1, u_0) \qquad (11)$$

Measures for WTP require that we specify the relationship between changes in $q$, income, and the spacing in these indifference curves. Normally we describe these as akin to substitution and income effects, but in fact they are interrelated. Thus, Diamond and Hausman's argument that concavity alone implies the "adding up" condition or Diamond's suggestion that income effects play a small role in his restrictive scope bound miss this point. Unless we select specifications for preferences that impose specific constraints (e.g., quasi linearity) we can expect that the curvature and spacing (or substitution and income effects) appear separate only at a point. Their interrelationship changes as we change either the level of the environmental resource or the level of well being. When the specification is simplified to abstract from the role of the income-utility link, it has implications for the role of substitution.

This can be seen in an example developed with Laura Osborne that changes the perfect substitution assumption and examines its role for both tests. Without this perfect substitution assumption all we can expect from a scope test is what the Arrow-Solow Panel proposed -- a large amount of the same object should have a greater measured WTP than a smaller amount (provided they are perceived this way by the respondents involved, see Smith and Osborne [1996]). Equally important the ratio of the sum of the WTP's associated with each of the components of a $\triangle q$ change to the WTP for the full $\triangle q$ can be substantially different from unity (unity is the value required by the adding-up

test), depending, again, on this substitution elasticity (see Kopp and Smith [forthcoming]).

I believe most environmental economists would agree on a few general responses to the four criteria for reliability of CV estimates based on the evidence to date. First, the scope test is not as big a "hurdle" for CV estimates as originally anticipated (i.e., several old and new CV studies have "passed" the NOAA Panel's standard).[34] Some recent examples illustrate the evidence for this conclusion. Laura Osborne and I performed a meta analysis (Smith and Osborne [1996]) of CV studies of visibility changes at national parks, including early and recent work. The variation across studies (and sub-samples in some individual cases) in the proposed visibility changes provide sufficient variation in the object of choice across independent sub-samples to develop a test. The estimates confirm statistically significant responsiveness in estimated WTP to the size of the visibility change. A study more specifically responsive to the Arrow-Solow Panel, is Carson et al. [1996]. Using in-person interviews and a CV design adhering to the NOAA guidelines, this study documents unambiguous responsiveness to the scope of the injuries explained to respondents. The choices of independent samples at each stated payment were significantly different for plans to accelerate the recovery of two different injury conditions. The estimated WTP for the plans were also significantly different. These findings are especially relevant to criticisms of CV because in contrast to much of the earlier evidence of responsiveness to scope, the object of choice in this study is unlikely to involve appreciable use values.

Even with modest sample sizes and a fairly complex specification for the attributes of environmental quality, CV estimates are consistent with responsiveness to

scope. One example supporting to this conclusion is a case where the object of choice was cleaning up marine debris on recreational beaches. Xiaolong Zhang, Ray Palmquist, and I used four independent samples with different photos to characterize debris levels and found significant differences in choices for control programs (see Smith et al. [1996]). In these cases, the levels of p-values for the tests are not as convincing as in the case of the Carson et al. study where nearly 3,000 households were interviewed. Nonetheless, even CV's critics now acknowledge the evidence of responsiveness in WTP to the "size" of the object of choice. The disagreement arises over what constitutes "adequate" responsiveness to scope and whether it can be documented in cases where primarily nonuse values would be provided by the environmental resources being evaluated.

Second, the adding-up test is, for practical purposes, infeasible and unlikely (for the reasons I cited earlier) to be informative. It requires a clear-cut quantitative metric for measuring the amount of the environment resource that is also understood by respondents in a way that is consistent with analyst's needs. These requirements imply that the framing task must convey reasons why the object of choice is partitioned in components.

Third, the Kahneman-Ritov condition seems hard to evaluate because it requires a clear-cut and uniformly shared standard (by respondents) for what are important versus trivial objects of choice. I have conducted one experiment (Smith [1996]) that indicates CV surveys can discriminate between different public goods. However, the direction of the distinction as to which object of choice was important was mine. I believe it would be accepted by a number of others judging the two programs. Nonetheless, there is

nothing in economic theory that requires people evaluate the personal importance of public goods the same way. This is one of the key difficulties in their proposal. Finally, most of the large scale (and many of the more limited) CV studies have reported choices (or WTP estimates) consistent with construct validity tests.

Overall, this record appears reasonably positive. Nonetheless, I do not feel this view is widely accepted among economists. Indeed, there is a curious dichotomy in the research using CV for nonmarket valuation. Environmental economists actively engaged in nonmarket valuation continue to pursue very technical implementation or estimation issues while the economics profession as a whole seems to regard the method as seriously flawed when compared with the indirect methods. They would no doubt regard this further technical research as foolish in light of what they judge to be serious problems with the method.

The overview in this section was intended to document reasons why the judgment of the profession at large does not seem to be consistent with the "realities" of using the indirect approaches for nonmarket valuation. Based on the evidence to date, CV and the indirect methods remain, in my judgment, on an equal footing.

## III. CALIBRATION AND CONJOINT ANALYSIS

### A. Background

While nonmarket valuation sometimes seems like a fairly new area of economic inquiry to economists in general, most in environmental economists recognize that both the travel cost and contingent valuation methods were proposed fifty years ago. Indeed, there has been some empirical experience with most of the methods for about thirty years.

By contrast, the two topics discussed in this section are quite new and as a result evidence on their performance and advantages in comparison to traditional methods more limited. It is not clear at this stage that either of these proposals will actually advance the practice of nonmarket valuation. Each seems to offer a promising line for future research.

## B. Calibration - Theory and Practice

The term calibration implies it is possible to adjust a measuring technique to a standard. As a rule we would expect this to mean the time value of the desired variable is known in at least one situation. Moreover, we must also have the information available to estimate this variable. Under these conditions, calibration calls for using the measuring technique (e.g., a hedonic property value model or CV survey) and typical information to estimate the value for this unknown variable. Because the "truth" is known, it becomes possible to adjust the method based on the discrepancies between its estimate and the true value. The reason for conducting the exercise is a presumption that some adjustment procedure can be developed that would be useful in situations where the true value is not known. Based on common dictionary definitions for calibration, the

logic seems to arise from the calibration of scientific instruments. I am not sure when the proposal to calibrate CV estimates was first made. Shortly after the Exxon sponsored symposium on contingent valuation (see Hausman [1993]) it was suggested that results from stated preference surveys in marketing research analyses were routinely calibrated to other information before they are used to project the demands for new products.

From these hazy beginnings, a number of participants in the activities associated with natural resource damage assessments sought to identify calibrating factors to adjust CV based WTP estimates.[35] NOAA's 1994 proposed regulations for damage assessment under the 1990 Oil Pollution Act (OPA) further heightened interest in the factor by posting a "target" calibration factor of fifty percent. The draft regulations suggested that:

> "Estimates of hypothetical willingness-to-pay (WTP) may incorporate biases in opposite directions. On the one hand, the appropriate measure of damages is willingness-to-accept (WTA) not WTP, . . . . There are theoretical arguments for why WTA may exceed WTP by a substantial margin in a natural resource context with relatively few substitutes . . . . On the other hand, several experimental studies (of lower quality survey design than proposed in this rule) suggest that stated intentions of WTP in CV surveys exceed observed responses in simulated markets . . . . Because of the various possible biases a discount factor is included in the proposed rule to apply to estimated WTP. The proposed rule gives a default factor of fifty percent for the purposes of soliciting comment. However, the trustee(s) may adopt a different calibration factor if it can be

shown that a different factor is appropriate for a specific application of CV." (NOAA [1994] p. 1140, emphasis added)."

Until the complete change in NOAA's position, displayed in the final regulations for damage assessment under OPA issued in January, 1996, this proposal further heightened interest in calibration.

Parallel to this discussion, Cameron [1992] and Morikawa [1989] (see also Morikawa, Ben-Akiva and McFadden [1990]) proposed different types of joint estimation combining the models developed from information about actual behavior with CV responses, when both sets of information were available for the same respondents.[36] This research will be the primary focus of my discussion of calibration.[37]

Cameron assumed a quadratic direct utility function in deriving a travel cost demand model for sport fishing and providing the behavioral framework to interpret CV responses. The key question included in her analysis was structured to consider the maximum total expenditures on fishing trips an individual would be willing to incur in a season before stopping fishing. Her approaches uses Roy's identity (as given in the first row of Table 1) and the indirect utility function (derived from this quadratic specification) to provide parametric restrictions across the two models. The restrictions for parameters shared between the two models mutually calibrates the two sources of information on recreation demand. Recently Chapman et al. [1996] have extended this logic to contingent behavior models (see also Englin and Cameron [1996]).

By contrast, behavioral models (as a source of parametric restrictions) do not serve a central role in the Morikawa, Ben-Akiva and McFadden framework. In this case the two data sets (one stated and one actual choices) permit estimation of the relative

scale factors associated with the errors from two discrete choice models, provided the other parameters are restricted to be equal. Thus, they assume identical behavioral functions for the stated and actual choices. The specification of the characteristics of each mode is assumed to be complete.

Several recent studies have replicated the basic logic of these two initial pioneering approaches. For example, Englin and Cameron [1996] use the initial Cameron logic to combine responses to repeated contingent behavior questions (i.e., how respondents indicate their recreation trips would change with several percentage increases in travel cost per trip) with an individual's actual trips. The responses are treated as a panel on each recreationist with the actual and stated responses assumed to arise from a common data generating behavioral framework.

Adamowicz et al. [1994] extend the Morikawa et al. logic to a RUM framework where the focus is on site choice. Considering actual and stated site decisions for recreational fishing, they restrict the preference parameters for variables measured in the two samples to be equal. This assumption allows the combined estimator to identify a relative scale factor (i.e., the ratio of the scale parameters for each error). Before turning to some further extensions to this calibration framework, some potentially important "details" in the models should be noted.

First, I believe that tasks associated with combining revealed and stated preference information increase the need to understand how respondents will be interpret the questions posed in stated preference surveys. To illustrate this point, consider Cameron's question:

> "If the total cost of all your saltwater fishing last year was $A more, would you have quit fishing completely?" (Cameron [1992] p. 305, the $A corresponds to a specified dollar amount.)

Her analysis assumes that people's answers to this question are based on a decision framework in which the number of trips can be altered in response to the proposed additional fixed charge. Whether this is correct depends on how respondents interpreted the conditioning phrase - "all your saltwater fishing last year." Another view of the question being posed is that the individual is being asked to assume he (or she) will take the same number of trips in the proposed new situation. This distinction changes the link between the indirect utility function governing the response to this question and the travel cost demand.[38] A similar issue arises in the Englin-Cameron application which asks about the number of fishing trips that would have been taken if the cost were a higher. Englin and Cameron assumed the cost corresponded to the travel cost for the average observed trip. Respondents could have interpreted cost as expenditures (i.e., travel cost times number of trips, with the number corresponding to the season the survey had just asked about). In this case the interpretation of the percentage increment as an increase in the unit price would be incorrect and the model used to link their responses would change.

A more general concern arises if we assume that there is some uncertainty at the time recreationists plan their trips. This formulation would imply a distinction between ex ante plans and ex post behavior.[39] It is not clear how respondents would interpret contingent questions under these conditions.

A third type of concern arises with the data collection strategy used in Adamowicz et al. Responses to multiple choice questions asked of the same respondent (64 sets of three alternative choices) are treated as independent in the statistical analysis. Moreover, in their case a data collection problem (see note #5 in their paper) required that they assume the revealed (RP) and stated preference (SP) responses are not correlated for each respondent. Cameron did not make this assumption. Nonetheless, arguments can be made to support either position when the data includes past (from the respondent's perspective) revealed preference information and current stated preference information. The Adamowicz et al. assumption of independence across stated choices seems less subject to debate and therefore more questionable.

The Adamowicz et al. approach is an example of a much larger set of research outside applications to the valuation of environmental resources. This other research seeks to combine RP and SP data for predicting choice or market shares (see Louviere [1996a, b]). In these other applications a common preference structure is assumed. The role of stated costs, partial attribute lists, and other distinctions between actual and stated choices is not explicitly considered. The primary goal is to estimate the relative scale parameter to adjust predictions about choices or to gauge the reliability of the types of data. Little attention is given to the behavioral foundations for the nonstochastic component of the models used in the analysis.

Three recent extensions to the Cameron proposal have been developed. The first of these by Young Sook Eom and me (Eom and Smith [1994]) focuses on using joint estimates to combine people's actual responses to an unobservable quality dimension of a commodity with their stated choices for variations in this attribute. The specific

application involves the health risks associated with pesticide residues on fresh produce. Taking advantage of Viscusi's [1989] prospective reference theory which assumes Bayesian updating of subjective probabilities our model considers how consumers respond to proposed increments in their (unobservable) baseline perceived health risks given specific product choices (fresh produce with and without pesticide residues). The model also uses a different approach to describe consumer preferences. After isolating a demand model that offers a good description of consumer demand for an aggregate of fresh produce (based on their actual purchases) we use the corresponding quasi-indirect utility function (adapted for the uncertainty in the choice process) to describe consumer preferences for the stated choices.

Finally, our analysis considered the influence of how consumers interpret the pricing condition. It poses a contingent choice question (between two types of produce) with a different price per unit for each produce variety in two different ways (one with a specific commodity identified and a second described as most frequently purchased). The demand model treats this as a component of a fixed weight aggregate demand for produce and evaluates the effects of different price descriptions across independent sub-samples. Our results suggest differences in how respondents answered the questions. Unfortunately, this effect could not be separated from the difference in definitions for the commodity price associated with each formulation. Thus, as Englin and Cameron's study, these respondent interpretations appear important to the form and plausibility of the behavioral restrictions in calibrated models.

Larson et al. [1993] considered a different modeling strategy. Based on the expenditure function corresponding to an Almost Ideal Demand System (Deaton and

Muelbauer [1980]), they use a composite model to estimate the total value of a resource enhancement, recognizing the use and nonuse values. The resource change involves increases in the gray whale population off California. Because the annual migration of this species supports a significant amount of recreation (e.g., whale-watching), the decision to travel to locations that provide opportunities for viewing the annual off-shore migration, is analyzed jointly with responses to a CV question offering to clean coastal waters, purchase additional calving habitat areas, and other interventions intended to increase the population. By recognizing the potential for differences in how individuals who participate in whale watching versus nonparticipants would respond to an open-ended CV question, Larson et al. were able to formulate a joint model linking the expenditure equation for whale watching recreation with the WTP function for enhancements in the population. The link is different for users and nonusers. Nonusers may have a positive value for enhancements in the population but their WTP is not influenced by the terms of use. By estimating these models jointly, with an identification of users versus nonusers, it is possible to adjust the models for each situation.

Xiaolong Zhang and I (Zhang and Smith [1996]) have used their basic logic to consider a more general formulation with variations in the pricing, type of resource, and respondent behavior in the joint estimation of the value of proposed changes in environmental quality. Our application involves marine debris as a source of quality deterioration for coastal resources. The design altered the types of resources (some available for beach recreation and others providing exclusively habitat for marine species), the proposed terms of payment for the plans to provide the improvement (i.e., lump sum payments versus beach access fees where total cost to the individual depends

on his(her) level of use), and questions intended to identify whether respondents used the resources affected by the proposed plan. The framework and survey design offer multiple ways for the behavior described in use and nonuse values to be "observed". For the most part, these variations affect the type of CV question asked as independently assigned design points across the respondents in our sample. Information about their actual recreational behavior was also collected and combined with responses to discrete choice questions.

A behavioral model recognizing the nonseparabilities between environmental quality (i.e., debris) and beach recreation, as well as the separable contribution associated with the nonuse values provides the overall framework for joint estimation. Zhang [1995] reports the results from a linearized version of the model that offers preliminary support for joint estimation of economic values that embody both use and nonuse dimensions.

All of the approaches I discussed as calibrated methods could also be described as convergent estimates. This terminology would parallel the use of convergent validity criteria in evaluating CV. Regardless of terminology, the frameworks developed here do not regard one approach as the true values and the other as estimates to be adjusted. Instead, they acknowledge a common unknown behavioral process should provide the basis for the choices that comprise each data type. Distinctions must be built into the description of the data generation process for each approach (i.e., indirect and CV). Thus, each study summarized here offers a variation on a joint or multiple equation estimator where a mix of a priori restrictions to preferences and the specific formulation of an individual's time and income constraints provide the basis for the cross equation

parameter restrictions. To implement these methods, the data available must include information about multiple types of choices (motivated by a common behavioral framework) from each individual.

At several points in the earlier discussion of travel cost models less formal approaches for using different benefit measures were introduced as calibrating adjustments. Indeed, the CV literature has a variety of proposals for using the results from laboratory experiments, theory, or both to adjust CV estimates (see Fox et al. [1994], Cummings et al. [1995]), and Bjornstad et al. [1996]). The distinction between these proposals and the methods described here is that in the approaches described above a consistent behavioral model provides the basis for the restrictions used in estimating these models. They are applied to the multiple types of behavior observed from a common set of individuals. The other methods do not have a common behavioral framework that is used to derive their proposed adjustments.

Similarly adjustments to benefit measures in the literature based on meta analyses or other procedures (e.g., Walsh et al. [1992]) have similar problems in that they do not have a direct link to a model of individual behavior.

This is not intended as an argument that they are inappropriate. Rather, the point is simple -- we have no basis for concluding (without experience and evaluation) that they will improve the properties of the resulting benefit estimates. By contrast, parametric calibration, as developed from Cameron's general logic, can be treated as a set of prior restrictions that offer the potential for improving the efficiency of the estimates. They have the potential for introducing bias should the restrictions be

incorrect.[40] Thus, the general strategy can then be evaluated by considering how prior and sample information contribute to the properties of an econometric estimator.

C. Conjoint Analysis

The prospects for using conjoint analysis in non-market valuation has attracted considerable attention among environmental economists.[41] The term actually refers to an array of methods that, as Louviere [1988] notes in his early review, focus on using individual evaluations constructed by a sample of respondents for a specified set of multiattribute alternatives to measure "part-worth utilities". In our terminology, the focus seems to be on methods for eliciting marginal WTP (or marginal rates of substitution) for specified changes in the characteristics of heterogeneous commodities.

Some of the earliest applications in environmental economics were associated with risk. Viscusi, Magat and Huber [1991], for example, used risk-risk tradeoffs to construct measures of the marginal WTP for changes in the risk of chronic bronchitis. Their approach considered pairwise comparisons and changes in different elements in economic lotteries (i.e., combinations of probabilities and stated outcomes with hypothesized implications for individual well-being) to isolate points of ex ante indifference for each respondent.

Two aspects of their strategy distinguish it from both open-ended and discrete choice CV questions. First, a specific reference situation is given and often the adjustments are made to non-monetary components of each lottery. For example, an individual would be asked to consider living in a community with a specified risk of being killed in an automobile accident and a risk of chronic bronchitis due to air pollution

versus another community with a different set of risks for each outcome (these scenarios would be structured so that the probability of a different outcome was lowest in each community). Respondents would then be asked to rank the two situations, based on where they would prefer to live. In the next stage of what is usually a computer based interview, they are asked to adjust a pre-specified variable (in this example one of the risks for one community) until they would be indifferent between the two communities.

The second distinction arises from using a model of how the indifference judgment is made to recover measures of economic value. That is, the interview process yields an "equivalence relationship" (given we accept conventional expected utility theory, as well as a variety of simplifying assumptions) between the health outcome (in my example chronic bronchitis) and an individual's evaluation of risks to his (or her) survival.[42] This link is then used with estimates of peoples' willingness to accept risks in the workplace (i.e., values of statistical lives, see Viscusi ([1993]) to estimate the ex ante monetary value of compensation for chronic bronchitis (based on the derived equivalence relationship).

The Adamovicz et al. calibration study relied on conjoint methods to develop the stated preference component of their sample. Multiple differentiated situations as sets of three alternatives were presented to each respondent and, as I noted, they were asked for a choice. This strategy is consistent with a RUM framework and appears to be the most active area of current research (see Louviere [1996b] and Adamowicz et al. [1994]).

Alternatively, the elicitation process can present pairs of alternatives and seek a rating of the degree of preference. In this case an ordered probit (or logit) model based

on utility differences assumed to arise from attribute differences would be estimated. (See Johnson et al. ([1995] and Desvousges et al. [1996] as recent examples).

It is too early to compare the performance of conjoint strategies with CV. More experience is needed for nonmarket objects of choice before an evaluation of this questioning mode for environmental resources can be developed. This qualification is important because some practitioners are concluding based on experience in marketing research that the method avoids (or substantially mitigates) the problems argued to be present with CV. There is no basis for this conclusion. Indeed, there are at least two issues that suggest caution in assuming the record of positive performance is relevant.

The first arises from the design of most conjoint methods. If the experience of double-bounded CV questions offers any guide to how individuals react to sequences of questions, then all conjoint studies, whether tradeoff adjustment, choice, or ratings, face problems. This conclusion follows because they rely on collecting multiple answers from each respondent. That is, sets of alternatives are presented to each individual and analyzed as if they were independent responses. The double bounded estimator as proposed by Hanemann et al. [1991] assumes a "perfect" correlation between responses to two discrete choice CV questions to develop interval estimates. Tests with several different applications suggest a high degree of consistency in the stochastic process generating the responses but sufficient differences to reject "perfect" correlation (see Hanemann and Kanninen [forthcoming]). To my knowledge, no one has considered the potential bias from assuming the question sequence presented to each individual in a conjoint study can be treated as a panel of uncorrelated responses.

A second, equally difficult, issue concerns the theoretical consistency of what is estimated. Rating and tradeoff models provide estimates of marginal WTP (or the marginal rate of substitution based on commodity to commodity comparisons). These are not measures of total WTP for a change in *q*, as defined by equation (2). The information recovered does not permit estimation of the WTP function without further a priori restrictions (including independence of the responses to the question sequence). Moreover, even the choice based conjoint models face a significant conceptual problem in measuring Hicksian WTP. They rely on the prior specification of a choice set for each respondent. IIA allows estimation of the parameters of simple RUM specifications, but not welfare measurement (see Kaoru et al. [1995] for discussion of the role of the full choice set for the definition of welfare measures in the context of travel cost models).

## IV. DISCUSSION

My title was selected to catch the reader's attention. However, it was not exclusively an effort to "sell" this review of where we stand in non-market valuation. It has another purpose as well - to call attention to the project orientation of most applied studies associated with one of the valuation methods. This orientation contrasts with the policy needs for what are often described as "transferable" benefit estimates or benefit functions.

There have been efforts to compare results from specific methods (travel cost, hedonic, and CV) using standardized benefit measures such as consumer surplus per trip

or the marginal WTP to a comparable change in air quality. Neither measure is a "price" in the usual sense. Indeed, as Morey [1994] has documented for the case of using consumer surplus per trip measures to compare travel cost demand and RUM estimates, there are significant theoretical problems.

Nonetheless, the needs for benefit measures are increasingly expressed in terms of some type of unit value. To meet these needs future research must begin to adopt strategies that parallel the theoretical and practical research that served to enhance the development of price indexes for marketed goods.

This strategy seems feasible for environmental resources that primarily give rise to use related values. Nonetheless, to meet this goal requires a change in the focus of research away from specifically defined resources to frameworks that seek to identify the attributes of resources that distinguish their contributions to different use values. Such a unified structure would be similar to what RUM and hedonic frameworks provide in describing how individuals make choices among sites with different characteristics, and provide links between these characteristics and benefit measures. My suggestion is that such models need to be developed more generally with the goal of consistent unit benefit functions. It implies that estimates will need to be regularly updated for the same environmental resources. It is only through this process that we could begin to judge whether environmental resources are in fact becoming more scarce over time.

This overall research strategy seems feasible for use related benefits because they are associated with goods and services that are exclusive and rival in consumption (i.e., they are more like private than public goods). Nonuse values, associated with public goods, are not as readily described as comparable to unit benefit functions.

Addressing the issues associated with the development of unit benefits or benefit indexes for public goods requires theoretical and empirical research. What is known is more limited and therefore further from being able to provide the transferable models (and the quantity measures) that would be required to formulate "unit benefit measures". Nonetheless for an important part of the issues addressed in environmental valuation, (i.e., those associated with use values). I believe it is possible to develop a new generation of research that parallels price index number development that routinely takes place in statistical bureaus around the world. Perhaps this transformation in our research strategy will be accomplished before nonmarket valuation celebrates its seventy-fifth birthday.

**Table 1: Choice Circumstances, Models, and Indirect Methods for Non Market Valuation**

| Method | Information Observed | Information Imputed | Behavioral Model Estimated | Link to WTP Function[a] |
|---|---|---|---|---|
| Travel Cost recreation demand | The quantity "demanded" of a recreation sets measured as: a visit rate with aggregate data; a count of visits, or a single site selection for a specific trip with individual data | The price as the "full" cost of using the recreation site, including the vehicle related travel costs, access charges; on-site time costs; incremental costs of equipment and supplies directly related to activity | Demand or random utility model | $x_i = \frac{-v_{p_i}}{v_m} = \left( \frac{-\frac{\partial WTP}{\partial p_i}}{1+\frac{\partial WTP}{\partial m}} \right)$ |
| Hedonic property (or wage) model | The housing price (or rent) for housing applications and the wage rate (hourly or annual) for wage models. Houses and jobs treated as differentiated goods so many different prices exist | People recognize attributes of houses; so equilibrium presumes no incentive to change; equilibrium assures that prices will be a function of attributes. Environmental resources enter as site specific amenities. | Hedonic price ($p_j$) (or wage) function | $\frac{\partial p_j}{\partial q} = \frac{v_q}{v_m} = \left( \frac{\frac{\partial WTP}{\partial q}}{\frac{\partial WTP}{\partial m} - 1} \right)$ |
| Averting Behavior (household production model) | An activity or actions that reflects implicit tradeoff of costs to meet a specific objective such as improved air or water quality experienced by the individual | Quantity and incremental costs that were assumed to comprise the complete tradeoff considered in deciding about the level of the averting or mitigating activity | Expenditure function or demand function for commodities ($x_r$) hypothesized to be involved in averting behavior; direct link to marginal WTP when $x_r$ is a perfect substitute for $q$ | $p_r \frac{\partial x_r}{\partial q} = \frac{v_q}{v_m} = \left( \frac{\frac{\partial WTP}{\partial q}}{\frac{\partial WTP}{\partial m} - 1} \right)$ |

[a]Subscripts to the indirect utility function refer to the partial derivative with respect to the identified argument, $v_q = \frac{\partial v}{\partial q}$.

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Footnotes

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[1] The first part of my title was selected to try to capture potential readers' attention but is not completely accurate. I will not devote the attention required to describe fully how the methods used to monetize economic values must be adapted to develop virtual prices. See Madden [1991], Morey [1994], Smith [1992] for an outline of the issues and Espinosa and Smith [1994] for further evaluation of alternate approaches.

[2] See Kopp and Smith [1993] for an overview of the statutes and practices of damage assessment as of 1993.

[3] This figure has been widely quoted in the national press at the outset of the 1996 summer season in the context of limitations on the National Park Service's resources. More generally see OECD [1991] for a discussion of the importance of domestic tourism in exports of key trading areas.

[4] It would be inappropriate to conclude that attention to nonmarket valuation resulted from a direct realization of the importance of the "environmental sector" through some systematic process of considering these types of aggregate expenditures. Interest in the US was prompted by requirements to undertake benefit-cost analyses for new major environmental regulations and, in 1989, to valuing the injuries due to releases of oil and hazardous substances. Benefit-cost mandates also prompted interest in other developed countries. Nonetheless, it is also likely that the origin of these mandates and support for continued efforts to maintain and improve environmental resources reflects consumers' preferences.

[5] A comparison of the real GDP estimates for the reported in Summers and Heston [1991] for 1988 indicates that 53 of the 62 developing nations in Africa and South America with real GDP under one percent of the U.S. level. The OECD [1991] reports estimates of pollution control expenditures in the mid 1980's at approximately 1.47 percent of

GDP for the U.S. and with estimates ranging from 0.82 to 1.52 percent for other member countries. (See Table 21 in the OECD). More recently Carlin et al. [1992] report annualized estimates of the costs for all U.S. pollution control (in 1986 dollars) at about 2.5 percent of GNP.

[6] Examples include Just, Hueth and Schmitz [1982], Johnasson [1987], Braden and Kolstad [1991] and now the greatly expanded revision by Freeman [1993]. Indeed, it may be hard to appreciate the various sources of confusion in the early literature given the existence of these volumes. Morey's [1984] overview, appropriately titled "Confuser Surplus", provides some perspective on the early confusions in interpreting consumer surplus measures.

[7] This formulation assumes no income changes and is sometimes described as a money metric.

[8] There are actually few direct measures of the quantities of market goods. As a rule we have measures of prices and expenditures on specific good. These are used to construct price indexes and then quantity indexes as expenditures on a class of commodities relative to the price index developed for that group. See Diewert [1993] for a discussion of the history of the theory and practice of construction of price and quantity indexes.

[9] These concerns were among the early motivations for Waugh's research on hedonic price functions for vegetables. He also conducted an early form of contingent valuation. He concluded his evaluation of both methods noting that:

> "It is evident from this discussion that the two methods [surveys of attitudes and preferences and market data on prices and quantitative measures of attributes] supply data of a different nature, and that they supplement rather than duplicate each other. . . . the ideal study of demand should use both methods." (Waugh [1929] P. 108, bracketed terms added).

[10] Of course, there are situations where problems of quality and quantity measurement do arise. This is especially true for new products or for improvements in the quality of product in the presence of technical change. Here the commodity improves and becomes less expensive over time so relative prices over that time do not provide a basis for gauging the quality differences. The case of micro-computers is one of the best examples of this situation. Se Nelson et al. [1994] for an example of a hedonic price model used to take account of quality changes in micro computers.

[11] Conventional economic measures for values cannot be defined where preferences are incompatible with substitution and the associated tradeoffs (i.e., in the case of lexiographic preferences). This is not incompatible with complementarity relationships between one (or more) goods and a nonmarket resource permitting measures of

economic value to be recovered from choices. In this case there are substitution relationships being used. The private good(s) included in the composite is (are) assumed to substitute for other private commodities.

[12] Bockstael and McConnell [1993] describe the conditions sufficient to develop this relationship. the non-market resource, *q*, should be a weak complement to a non-essential private good, say $x_i$. The non-essential requirement is needed because weak complementarity is imposed when the demand for $x_i$ is zero. In addition they should satisfy the Willig [1978] condition. This corresponds to any one of three mutually dependent conditions:

(a) $v_q / v_{p_i}$ is independent of income;

(b) consumer surplus per unit of the associated commodity is independent of

(c) $v_q / v_{p_i} = \int x_{iq}\, dp_i / x_i$

For more details on the implications of these conditions see pp 1253-1255.

[13] This follows because the arguments in equation (2) that are specified to change will be different. For example the WTP for access to a resource that provides the non-market resource (designated here as $\overline{WTP}$) would be given as:

$$\overline{WTP} = m_0 - e(p^*, q, v(p, q, m_0))$$

p* replaces the element of the price vector corresponding to the good related to q with its choke price. In this case the change in the $\overline{WTP}$ within *q* is given as:

$$\frac{\partial \overline{WTP}}{\partial q} = -\frac{\partial e}{\partial q} - \frac{\partial e}{\partial v} \cdot \frac{\partial v}{\partial q}$$

With weak complementarity between the private good and *q*, the first term in this expression is zero. See McConnell [1990] for further discussion of other examples.

[14] For a summary of the early arguments about the treatment of zonal data see Bockstael, Hanemann and Strand [1987]. More recently, this issue has been discussed for individual observations as an excess zero" problem (see Haab and McConnell [1996] and Shonkwiler and Shaw [forthcoming].

[15] See Hanemann [1984b], Morey et al. [1995] for discussion of the modeling strategies for extreme and generalized corner solution problems.

[16] This simple formulation imposes a normalization rule on the scale parameter. See Louviere [1996b] for a discussion of this issue in the context of combining data where the scale parameters are different.

[17] Hausman et al. [1995] suggest that their specification combines a discrete choice model with a utility-consistent count model. In their terms it " . . . encompasses both the number of trips (purchases) and the sites for each trip (brand choice)." (p. 13). There are two difficulties with their proposed consistent link. The first is unique to the travel cost application and is shared by all the other proposed approaches for consistent links between site choice and seasonal demand. It arises when the travel cost is specified to include a time cost of travel. The model (and their derivation) assumes that the "prices" of sites are exogeneous. Indeed time allocation decisions are treated as separable, when in fact most of the evidence suggests this is inappropriate. While Hausman et al. offer an imaginative estimate of the opportunity cost of time, using travel mode data this is treated as a per trip decision separable from the allocation of time within a season. Most of the other recreation literature would question this assumption. Of course, to be fair to them, they are not alone in the assumption. Most applications have used a less sophisticated approach. My point is only that the full details of the link between seasonal usage and site choice needs to consider how this opportunity cost of time varies with the level and timing of use over the season.

A more specific concern with the mechanics of their link arises with the quantity measure. They argue that the measured expenditures on fishing trips of an individual when divided by the inclusive value from the RUM specification will be equal to the number of trips. As a rule, this would only be true if the individual visited only one site. Expenditures for fishing trips to K different sites, $y_F$ in the Hausman et al. notation, would be the sum of the expenditures on trips to each site as given below.

$$y_F = \sum_j p_{tj} T_j \text{ , with } p_{tj} \text{ = travel and time costs to site } j, T_j \text{ = trips to site } j$$

There is no reason to believe that $\sum T_j$ , which is the total trips will be equal to $y_F$ scaled by the inclusive value as they suggest in a key step of their derivation (P. 12). that is:

$$\frac{\sum p_{tj} T_j}{\frac{1}{\gamma}\ln(\sum \exp(\gamma\, p_{tj}))} \neq \sum T_j$$

It would seem that the link they propose requires a different measure for the total quantity of use, more consistent with the left side of the above equation as a quantity index for site usage so the product of the price index (the denominator of the left side) and the quantity index equals the relevant total expenditures, $y_{F.}$

[18] Brown and Mendelsohn [1984] proposed the hedonic travel cost model as a recreation analog to the hedonic property value model. Unfortunately, market equilibrium cannot be relied upon to provide the price (travel cost) function. This conclusion follows because the travel cost is an imputed price that the analyst assumes is perceived by each individual, not one established through market interactions. Smith et al. [1991] have suggested an alternative interpretation of the function as a locus describing how individuals conceive of the substitution alternatives available to them. However, there is not a priori basis for evaluating the reliability of this description of how substitution influences people's choices.

[19] Vaughan et al. [1985] provides to my knowledge first recognition of this possibility and an application.

[20] These same types of interconnections could be suggested for hedonic and averting behavior models where multiple sets of goods are combined to produce amenities. Carol Gilbert and I proposed using such connections along with the durability of the marketed good being used to estimate long run versus short run benefits (see Gilbert and Smith [1985]). I am grateful to Alan Randall for making this general point and suggesting the difficulties posed by formulating individual partial models for each type of adjustment when multiple household production processes may be taking place.

[21] I will use calibration in several different ways in this discussion. All are intended to imply that estimates are developed from a composite of sources. Later I discuss proposals for joint estimation. Here a calibrated assessment is intended to mean an evaluation of benefit estimates for the same resource change derived from independent sources, combined with attempts to understand the sources of the differences and develop a "best" estimate from the process. It can be somewhat informal as in Freeman's [1982] early evaluation of the aggregate benefits of clean air and water programs or statistical as in the Banzhaf et al. [forthcoming] comparison of methods used to estimate the economic damages from air pollution for social costing of electricity.

[22] One interpretation of this process is that it is an attempt to provide a theoretical model to describe relationships one should expect to find in a meta analysis of different approaches (i.e., micro and aggregate) to measuring benefits for a common environmental resource.

[23] The record may not be as clear cut as this comment suggests. Alan Randall, after reviewing an earlier draft of this paper, argued that the evidence for submarkets has often been imposed on the empirical studies. My own experience is based on a study with Greg Michael's (see Michael and Smith [1990]) where we found realtors identified sub-markets for suburban Boston and these were confirmed by the differences in the estimates of the hedonic price functions. It is also the case that to my knowledge there have been few studies since the Straszheim [1978] study that tested for market segmentation.

[24] As a rule, wage hedonic models have been estimated with national samples and regional dummy variables included to take account of local conditions in each area. Because there is evidence that the model is more effective in recovering the wage-risk tradeoff with blue collar workers (see Viscusi [1993]) where we might expect more limited knowledge of opportunities in other regions one might also argue that wage models should be evaluated for separate geographic areas as sub-markets. This would parallel the market segmentation in hedonic applications to housing markets. Under these conditions it would be foolish to base the model used in estimating quality of life indexes on a framework that assumes a national market equilibrium.

[25] The value of a statistical life is the aggregate willingness to pay to reduce the risk of death. In order to make this measure tangible one must specify the size of the risk change and the number of people over which the individual willingness to pay is being summed. Johansson [1995, p. 61] described the process as aggregate WTP to save *b* lives by the group (say *n* individuals who experience the (*b/n*) risk reduction. This is reported by life saved (i.e., the aggregate divided by b) to be labeled the statistical value of a life.

[26] Of course, we assume they recognize these options and make them. If they did not, then there would be no scope for the indirect methods I summarized earlier.

[27] This result follows from Smith and Osborne [1996]. Equation (8) is a generalization to the quasi-linear form they discuss to evaluate expectations for scope effects.

[28] The reason for this conclusion is that the need for use of CV is greatest in monetizing nonuse values. Because these economic values arise from pure public good services of environmental resources, it is difficult to envision a situation where an enforceable contract could be offered to participants in an experiment. Once a donation vehicle is used the link to CV is completely changed. As noted earlier economic values estimated with CV or any method

require choices that connect objects of choice to something that is given up (actual choice) or proposed to be given up (CV). With a donation people may perceive that the object of choice is available with no tradeoff required.

[29] More specifically, they conclude that:

> "We have re-analyzed perhaps the best known such validation of CV, the Dickie, Fisher, Gerking (1987) paper. We find, using a non-parametric approach, that the hypothetical CV responses significantly overstate the actual market responses, both in terms of consumer demand and in terms of consumer surplus." (p. 11)

[30] This conclusion was based on comparing estimated price and income coefficients using a Poisson count estimator (see footnote #28 in my paper, printing errors deleted a minus for one of the price coefficients and decimal points for two of the estimated parameters in the models developed with actual sale data). The relevant issue is the degree of consistency that should be expected with micro data and a small sample. Hausman and Leonard impose a stringent standard in their analysis and draw rather general conclusions when it is not satisfied, noting that:

> "Our findings suggest that the CV method does not provide a reliable estimate for consumer surplus even in this most ideal of situations. Given such a large upward bias for a familiar market good like strawberries, we find no reason to believe that the performance of CV for unfamiliar environmental goods will be any better" (p. 11)

[31] The specific results are given in the table below. When the Cummings et al. sample is split based on those who own versus do not own calculators, there is no significant difference in the revealed preference (RP) and stated preference (SP) at the five percent level.

| | **Percent of Sample** | | | |
|---|---|---|---|---|
| | **Own Calculator** | | **Do Not Own a Calculator** | |
| **Decision** | **RP** | **SP** | **RP** | **SP** |
| Purchase | 57.1 | 45.4 | 8.3 | 1.6 |

| | | | | |
|---|---|---|---|---|
| Not Purchase | 42.9 | 54.6 | 91.7 | 98.4 |
| P-value | | | | |
| $\chi^2$ | 0.529(NR) | | 0.086(NR) | |
| Fisher-exact | 0.712(NR) | | 0.111(NR) | |

[32] The issue is how one treats individuals who did not return requests in the real and hypothetical samples. If we assume their values are zero then there will be wide discrepancies in the estimated WTP from actual and stated responses. If the analysis is confined to a comparison of the actual and hypothetical responses there is no significant difference based on each sample's estimates for WTP.

[33] In a follow-up set of comments, a subset of the original NOAA Panel authors (see Arrow et al. [1994]) offered clarifying comments on the meaning of adequate responsiveness to scope. Their comments were prepared in reaction to the scope test in the January 1994 proposed rules. They note that:

> "The proposed scope test is built to assure that there is a statistically detectable sensitivity to scope. This is, in our opinion, an improper interpretation of the word "adequately". Had the panel thought that something as straight-forward as statistical measurability were the proper way to define sensitivity, then we would (or should) have opted for language to that effect. A better word than "adequate" would have been "plausible". A survey instrument is judged unreliable if it yields estimates which are implausibly unresponsive to the scope of the insult. This, of course, is a judgment call, and cannot be tested in a context-free manner, as would be the case if the proposed scope test were implemented" (Arrow et al. [1994] p. 1).

[34] Hanemann [1996], for example, notes there is extensive evidence of responsiveness to scope. Among the studies he sites is Carson's [1995] review of 27 tests of scope. Overall he indicates that there have been at least 130 tests of scope. Reviewers more critical of CV have argued that most of these tests involve environmental resources with substantial use values reflected in the CV responses. In their view the scope issue remains to be evaluated for cases where WTP is dominated by nonuse values.

[35] Desvousges et al. [1995] describe four types of calibration relationships:

(1) ratio of average stated to "actual" values

(2) ratio of the number of individuals who say they will purchase a commodity at a posted price to the number who actually purchase it at that price

(3) stated and actual demand curves

(4) a function that can be used to adjust CV values depending on the specific parameters of the CV study.

Based on this structure the first approach is only available in experimental or simulated markets and one can easily question whether the "actual" value is known for anything used in these experiments (except as a monetary incentive).

[36] Cameron's paper [1992] was prepared about the same time as Morikawa's thesis and had been circulating under a different title since 1988.

[37] See Desvousges et al. [1995] and Mansfield [1996] for discussion of the use of simulated market data to develop calibrating functions.

[38] The quadratic specification has closed form expressions for both commodity demand functions and the indirect utility function.

[39] I am grateful to Per Olov Johnsson for calling this issue to my attention. To some degree, the Eom-Smith [1994] model is forced to deal with the issue because both choices involve decisions that convey commodities and risk of a health effect (i.e., cancer due to exposure to pesticides). We account for changes in beliefs as information evolves using the Viscusi [1989] prospective reference framework. In principle one could use a lottery framework and the actual outcomes to evaluate an ex ante - ex post distinction.

[40] An approach using a consistent behavioral framework is also what Mansfield [1996] has recently suggested for comparing simulated and CV experiments and within different CV surveys for discriminating among proposed data generation processes.

[41] It is mentioned in the revised NOAA regulations for damage assessments as a promising approach for estimating habitat equivalency.

[42] The approach used in this derivation assumes a simple form for the expected utility model with

$v(b)$ = utility realized with chronic bronchitis, holding all else equal (i.e., an indirect utility function with income and prices fixed)

| | | |
|---|---|---|
| *v(h)* | = | utility realized in a "healthy state without chronic bronchitis |
| *v(d)* | = | utility perceived ex ante of dying in automobile accident (e.g., altruistic concerns) |
| $\pi_b^i$ | = | stated probability of having chronic bronchitis in community *i* (*i = 1, 2)* |
| $\pi_d^i$ | = | stated probability of dying in automobile accident in community *i*. |

For an individual to be indifferent between communities 1 and 2, it must be that:

$$\pi_b^1 v(b) + \pi_d^1 v(d) + (1-\pi_b^1 - \pi_d^1) v(h) = \pi_b^2 v(b) + \pi_d^2 v(d) + (1-\pi_b^2 - \pi_d^2) v(h)$$

re-arranging terms we can express *v(b)* in terms of the standard gamble associated with decisions involving risks to life as:

$$v(b) = \frac{(\pi_d^2 - \pi_d^1)}{(\pi_b^1 - \pi_b^2)} v(d) + \left(1 - \frac{(\pi_d^2 - \pi_d^1)}{(\pi_b^1 - \pi_b^2)}\right) v(h)$$

For more details see Viscusi et al. [1991].