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ENVIRONMENTAL RESOURCE VALUATION: SOME PROBLEMS OF SPECIFICATION AND IDENTIFICATION

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ABSTRACT

Three significant characteristics of resource consumption are introduced into the decision-making process: time costs of consumption; a costly access activity; and, mutual exclusivity of (some) consumption activities. It is seen that when these factors are ignored approaches based upon estimation of a resource demand relationship are likely to yield either overestimates of a resource's value or no useful information at all. The difficulties identified here are shown to be directly relevant to the Travel Cost Method, and to be distinct from identification problems previously discussed in the literature. While the analysis suggests that the Contingent Valuation Method may be necessary to obtain useful estimates of resource values, it is shown that this approach, as commonly applied, does not yield the marginal evaluation information essential for policy prescription.

*This is a revised draft of a paper written while I was Visiting Professor of Economics at the University of Western Ontario in 1998. I am grateful for comments by David Burgess, Jim Davies, Glenn Harrison, David Laidler and other participants at seminars at that university, at Carleton University and at the University of Victoria. This draft should not be quoted without the permission of the author. Parts of the paper draw on earlier work by the author, Appendix A of an unpublished report, SACES (1997). Comments are welcome and should be sent to: mburns@ccs.carleton.ca

I. INTRODUCTION

Driven by global concerns to achieve better environmental resource management, a voluminous literature has developed addressing the methodologies that seek to yield the benefit and cost information essential for policy prescription. The quest for superior methodologies has generated, in an often quite technical form, developments in economic theory and in econometric methodology. Optimal policy management requires both total and marginal measures of a resource's value and to estimate these measures one of three approaches has usually been adopted: the *Hedonic Price* approach, the *Travel Cost Method* and *Contingent Valuation*. None of these approaches has escaped critical attention.

This paper contributes to the existing literature in the following manner. In Section 2 is a brief overview of the key approaches to resource evaluation while, in Section 3, the simple geometry of welfare measurement is reviewed and extended to take into account time costs of consumption. In Section 4 two further significant characteristics of resource consumption are introduced into the decision-making process: a costly access activity; and, mutual exclusivity of (some) consumption activities. It is seen that when these factors are ignored approaches based upon estimation of a resource demand relationship are likely to yield either overestimates of a resource's value or no useful information at all. The difficulties identified here are shown in Section 5 to be directly relevant to the Travel Cost Method (hereafter TCM) and to be distinct from identification problems previously discussed in the literature. While the analysis suggests that the Contingent Valuation Methods (hereafter CVM) may be necessary to obtain useful estimates of resource values, it is shown in Section 6 that this approach, as commonly applied, does not yield the marginal evaluation information essential for policy prescription.

II. BACKGROUND TO BASIC ANALYTICAL FRAMEWORK

The evaluation of environmental resources is now established as a distinct and major area of economic research. Although new analyses and results are continuously appearing in the literature, Braden and Kolstad (1991) offers a comprehensive coverage of the basic analytical framework and existing methodologies while more concise overviews are to be found in Coller and Harrison (1995) and in papers in the special issue of the *Journal of Economic Perspectives* by Diamond and Hausman (1994), Hanemann (1994), and Portney (1994).

Not all of the issues discussed in the literature are central to our concerns here. More briefly it may be noted that the evaluation of environmental resources must frequently take place without market data being available and, for the purposes of the present paper, that the approaches that have been adopted may conveniently be split into two categories:

- demand focussed approaches, which include TCM, which seek to infer properties of demand relations and then to derive resource valuations from consumer surplus type measures associated with these demand relations;
- willingness-to-pay (WTP) focussed approaches, which include most CVM studies, which seek to identify directly the WTP functions.

Of interest, *Hedonic* approaches can actually fall into either of these two categories, but these will not be considered here. Within this context it is relevant, however, to consider briefly how the extensions to the decision-making framework considered in this paper relate to the existing literature which, broadly speaking, has CVM and TCM associated with somewhat different approaches to the consumer decision process. The former approach has received greater attention in the recent literature and despite the WTP focus has developed around traditional demand and welfare analysis but applied in situations embodying zero priced resources, often with public good characteristics and generally involving a form of quantity rationing. These considerations have been associated with a number of valuable extensions to the results of Hicksian demand theory, as in Randall and Stoll (1980), Neary and Roberts (1980), Madden (1991) and Hanemann (1991). The formulation of the (hypothetical) consumer decision process that flows naturally from this approach, and also used in the CVM survey article by Fisher (1996), is given by:

$$\text{Max } U(x,z) \text{ s.t. } \Sigma\, p_i\, x_i = Y \qquad [1]$$

where x is a vector of consumption goods or services purchased at hypothetical income and prices, Y and p_i , under normal market conditions, and z is a vector of fixed quantities of environmental resources presumably with non-excludable characteristics.

This literature has gone some way towards incorporating some of the complexities that arise from activity based consumer models, as for example with the use by Hanemann (1991) of Maler's (1974) notion of *weak complementarity.* This concept enables variables (such as quality) to be introduced which affect utility, but only if the associated good or activity has a non-zero consumption level. Possibly because the writers in these fields have chosen to explore models where the approaches to standard demand and duality theory can still be applied, the CVM literature appears mainly to have steered clear of the model variations that would be suggested by the household consumption technology and value-of-time approaches initiated by Ironmonger (1972), Becker (1965) and Lancaster (1966 and 1979). Mutual exclusivity of activities appear not to have been considered.

By contrast, value-of-time and consumption technology (but again, not mutual exclusivity) lie at the heart of TCM, even if the kind of formal modelling implied by these considerations has played only a limited role in TCM literature. In the recent literature, for example, McKean, Johnson and Walsh (1995) explore value- of-time issues in TCM, but neither these authors nor Layman, Boyle and Criddle (1996) in an integrated CVM/TCM study go beyond simple modelling of resource access and consumption. Thus, even though the general economics literature has certainly explored welfare evaluation within a very general consumption technology framework, as in Burns (1979), in terms of formal modelling the TCM does not appear to have gone beyond the Becker-type “full price” formulation used by Randall (1994), and then in a context that was critical of the methodology. This limited extension is, however, a useful starting point for our considerations.

III. WELFARE MEASURES AND TIME COSTS OF CONSUMPTION

It seems uncontroversial that account should be taken of the time input into environmental resource consumption, and of the opportunity cost of that time. This is equally true whether it is `services= from a national park being consumed or time being used up in recreational or even commercial fishing. The simplified framework, building on the illustrative specification used by Becker and Randall, yields a modified maximisation problem

max U(x) s.t. 3 p_i^* x_i = Y^* [2]

where x is now a vector of all consumption goods and services (including environmental resources), p_i^* is the Afull price@ of the i^{th} good or service and is given by $p_i + wt_i$ and Y^* is Afull@ or potential income as measured by A + wT. Here the opportunity cost of time is measured by the wage rate, w, while t_i is the time taken to consume a unit of the i^{th} good or service, T is the total time available to allocate between work and consumption and A is a standard fixed income component. Work itself is assumed not to enter the utility function.

Particular limitations of this formulation to be noted here are: that there is no accounting for travel to a resource as a distinct but associated activity to resource consumption; the absence of any explicit or implicit two-part pricing arrangements associated with consumption activities; and, importantly, consumption of one good or service is not assumed to exclude simultaneous consumption of any other good or service.

On this basis the maximisation problem yields all the usual demand and duality results, but with the standard *p* and *Y* variables being replaced by Afull prices and income@, p^* and Y^*. Similarly modified welfare expressions are also easily derived, as can the quantity rationing results suggested by Neary and Roberts as well as expressions defining the possible differences between various willingness-to-pay (WTP) and willingness-to-accept (WTA) measures as explored by Willig (1976), Randall and Stoll (1980) and Hanemann (1991). There are of course a further range of well understood problems associated with welfare measures, as explained and summarised for example in Burns (1979) and in Just, Hueth and Schmitz (1982). These issues are not central to our concerns in this paper will not be pursued here. Some of the relationships between the resulting (WTP) and (WTA) measures are captured in the `modified= standard diagrams shown in Figure 1.

It is useful to interpret and illustrate the welfare measures for an individual that derive from this modified choice framework and in Figures 1a and 1b respectively are the standard indifference curves and demand diagrams, but here embodying Afull income@ and Afull prices@ instead of the usual income and price variables. The situation shown here is where an individual can allocate their full income to the consumption of goods and services other than the environmental resource X, and achieve utility level U_0. Alternatively, they can allocate some of their income to consuming X which is available at a per unit full price p^*. This way, by consuming the bundle (Y_1, X_0) they can achieve utility level U_1.

Two things are worth noting about these diagrams. In Figure 1a, in order to keep the diagram as uncluttered as possible, the indifference curve U_0 has been positioned so that the budget constraint reflecting price p^* and tangent to U_0 meets the vertical axis at “income” level Y_1 although this need not be the case. In Figure 1b however, the coincidence of the price intercepts of the Marshallian demand curve M(Y_0) and the Hicksian demand curve H(U_0) is not an expository device but follows directly from the specification of this situation provided above.

Various welfare measures can be easily distinguished here. Defining WTP and WTA as `total= measures, including amounts paid for consumption, consider first the measures that apply when the individual is allowed to vary the quantity of X. This would be so, for example, when individuals choose how long to remain in a park or, in a more complicated probabilistic sense, how many fish to catch. Here the relevant WTP expression, which is directly associated with the Compensating Variation (CV) measure, is defined in terms of WTP to be able to purchase X at a per unit price of p^* rather than have zero X. Its magnitude, reflecting both amounts paid and consumer surplus, is given by (Y_0 - Y_2) in Figure 1a and by ($a + e$) in Figure 1b.

This magnitude can be compared with the WTP obtained in the rationed case where either X_0 is consumed or zero X. Here total WTP is given by (Y_0 - Y_3) in Figure 1a, or by ($a + e + b$) in Figure 1b, the greater magnitude being obtained than in the unrationed case reflecting the greater reference quantity. As would be expected, however, consumer surplus is greater in the unconstrained case, being ($Y_0 – Y_1$) rather than ($Y_0 – Y_c$) in Figure 1a and (e) rather than ($e - c - d$) in Figure 1b.

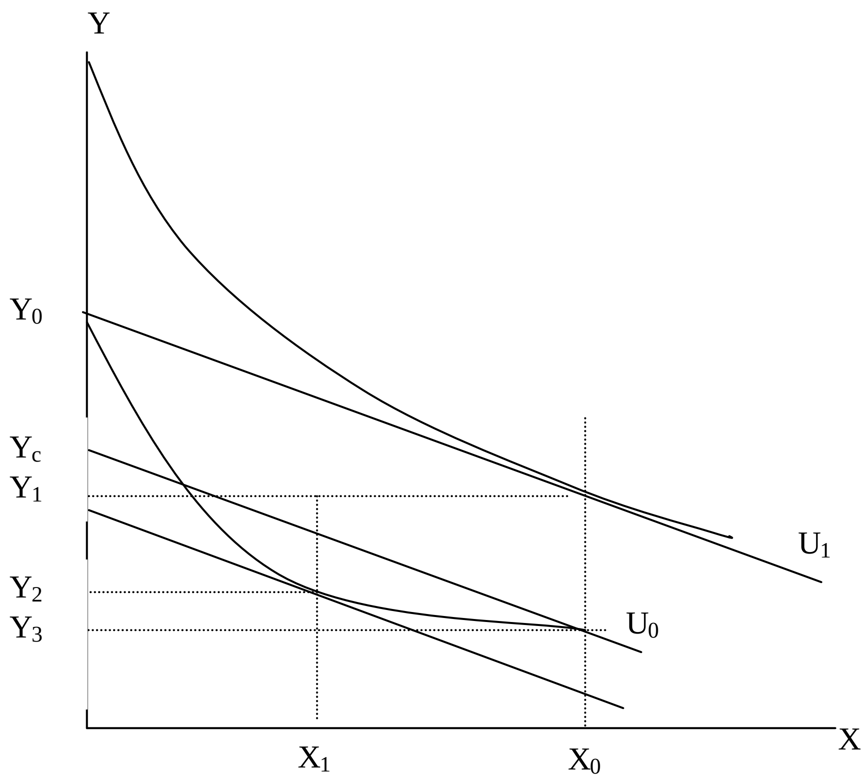

FIGURE 1a

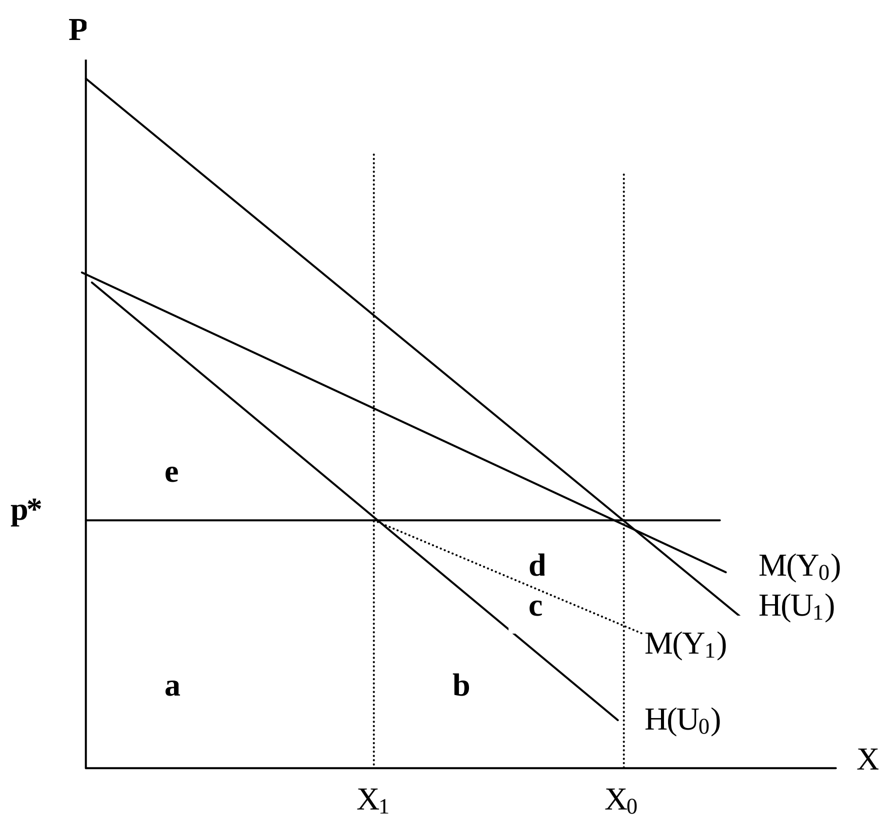

FIGURE 1b

Note that the linearisation of the demand curves for expositional purposes in Figure 1b has led to some imprecision in the relative magnitudes of the measures shown. Using an analogous approach to that adopted above the WTA measures can be similarly identified, for both the unconstrained and rationed cases.

Despite the apparently 'standard' nature of this analysis there are a number of features of this approach that make welfare evaluation a far more complex matter than in the standard case. First, note that the $p*$, which are not observable, will differ from individual to individual. The observable measures of the form $-x_i .dp_i$ will only be valid if w and t_i remain constant. Demand functions based upon usual price and income variables will be misspecified, have the wrong slope and yield incorrect consumer surplus measures wherever w and/or t_i vary with prices.

At the aggregate level further difficulties arise. When wages changes are the cause of the changes in $p*$ these changes in $p*$ will vary across individuals and an aggregate demand curve specified in terms $p*$ will no longer exist. It would therefore no longer be possible to calculate any of the aggregate WTP or WTA measures discussed above on the basis of standard market demand estimation.

IV. SOME EXTENSIONS TO THE BASIC MODEL

Having described a basic illustrative framework it is now instructive to consider two extensions to that framework that reflect important influencing factors in environmental consumption decisions. No effort is made to capture the degree of generalisation explored from alternative perspectives in Burns (1979), while the extensions themselves are introduced at the simplest possible level. Even these modest extensions, involving distinct access components and mutual exclusivity of some activities, have major implications for the analysis of environmental consumption activities.

As a simplification we shall initially focus on the case where a particular consumption activity, such as going fishing or visiting a national park, is undertaken only once within the time period over which demand is defined. In the following section we shall extend the analysis to allow for a particular activity being undertaken more than once in the time period in question.

Travel to the Resource and Access Charges

Environmental resource consumption, as with virtually all consumption activities, will involve a travel component that must necessarily be treated as distinct from the activity of resource consumption. Following Burns, if the utility yielding characteristics of a consumption activity are reflected by a production function where time, goods and services are inputs and if activity-specific input value constraints apply, then the (marginal) values of an input such as time will vary across activities. More specifically, the (marginal) value of time spent in a car on a congested highway returning to the city following a holiday outing to a recreational area will not be the same as the (marginal) value of time spent at the recreational area itself.

There is a problem here in that once we start separating activities, Pandora's Box has indeed been opened, and a question arises as to just how far we go. The value of time spent travelling to the ski slopes is not the same as the value of time spent queuing to get on the chairlift, which in turn will differ with respect to time in the chairlift and time skiing. Useful insights, however, can be derived from the simplest version of the model which involves separating only travel time from time spent `consuming the resource'. As a further simplification we shall not explore whether utility or disutility of travel time can be handled through assumptions of weak complementarity or otherwise. Finally, it will be initially assumed here that travel to and from the resource site is utility neutral so the costs of travel to and from the site, which will vary with distance in the usually assumed manner, will be exactly analogous to an access charge or a component of a simple two-part price.

Insight into the modified situation can be obtained again from consideration of Figures 1a and 1b above. For the time being it is still being assumed that participation in one consumption activity does not preclude the simultaneous participation in other consumption activities. For expositional simplicity we will again focus on the WTP measures and what can be seen immediately is that `total' WTP measures *for any given quantity* of *X* are unchanged by the introduction of a utility-neutral access charge. Assuming *X* is a normal good, however, chosen consumption of *X* for given p^* will clearly decrease as a consequence of the income effect. In addition, for any given quantity of *X*, consumer surplus reduces by the amount of the access charge. However, the sum of all payments for *X* plus consumer surplus remains equal to the same total WTP *for that quantity* as would have obtained had there been no access charge.

Access charges do introduce one major change to the standard model of consumer choice. The maximum access charge that any individual would be willing to pay and still consume *X* is given by the CV consumer surplus measure. With reference to Figure 1a again, the quantity chosen with this maximum access charge will be X_1 which is significantly non-zero. At this point any marginal increase in price or in access charge will cause an activity switch and discontinuous jump to zero in the consumption of *X*.

The more general effects of an access charge are shown in Figure 2 below, using a simplified version of the price-quantity framework of Figure 1b. Here the curve $M(Y_a)$ reflects the income effect of an access charge $A and shows quantity X_a being consumed at price P_0. The interception of $M(Y_a)$ and $H(U_0)$ identifies the *choke* price P_a at which the individual is now no better off than if he did not consume resource *X*. Total WTP to consume *X* at price P_0 , including the purchase price, access charge and consumer's surplus, is still equal to the area ($a + e$) shown in Figure 1b but now shown as ($a+e_1 + e_2$) in Figure 2. Here, however, the surplus is now only e_1, the residual area e_2 reflecting the access charge $A.

Mutually Exclusive Activities

Incorporation of access components and mutual exclusivity into the decision-making process make modelling and analysis of this process mathematically complex. The discontinuities introduced by the consequent switching of activities preclude the use of standard optimisation techniques although many of the usual comparative static results, defined in relation to full prices and income, will still apply between activity switches. Given, however, that access components and mutual exclusivity will apply to many consumption activities and also that marginal changes in one market may provide activity switches external to that market, this range of applicability is likely to be extremely limited. In fact the modelling implications of the model extensions have been nowhere near fully explored. All the same, useful insights can be obtained using a simplified approach.

As discussed in Burns (1979), if we were to list all of the activities which may be considered by individuals there are at least three factors that influence whether a particular combination or sequence of activities can be undertaken. Activities must be sequentially and locationally consistent while, in addition, many activities have characteristics that preclude simultaneous participation in most if not all other activities.

The approach here will be to assume that individuals' rankings are only defined over locationally and sequentially consistent combinations of activities, but for example, that consumption of a particular environmental resource precludes consumption of the most preferred alternative activity. More specifically, suppose that compared to consuming neither *X* nor *Z* an individual can achieve a non-marginal increase in utility by undertaking either a preferred activity *X* or a less preferred activity *Z*. This situation is illustrated in Figure 3 below. Here again the price-quantity framework of Figure 2 has been adopted, but with an additional Hicksian demand curve, $H(U_z)$. Had the individual chosen to consume Z at the associated access charge and per unit full price a utility level U_z would have been obtained, where $U_0 < U_z < U_a$ and where U_a is the utility level attainable when X is available at per unit price P_0 and access change $A. Since U_z is now the reference base utility level, X would not be consumed at any (p, Y) combination yielding less utility than U_z and there is therefore no need to extend any Marshallian demand curve left of $H(U_z)$. At price P_0 and access charge A the individual would consume quantity X_a, as in the situation illustrated in Figure 2, but now if the per unit price was to rise, a lower *choke price* P_z would cut in and the individual would switch from consuming X_z units of X to consuming no X but a significantly non-zero quantity of Z.

In Figure 3 the relevant valuation areas e_1 and e_2 are now bounded by $H(U_Z)$ rather than $H(U_0)$. The area e_2 measures the access change and must exactly equal the area e_2 in Figure 2 although the device of using linear relations may suggest otherwise. The consumer surplus associated with the consumption of X is smaller than in the previous case and shown by the area e_1, which clearly tends to zero as U_z tends towards U_a as defined above. In effect the relevant curve for calculating WTP is $H(U_Z)$ but only up to price level p_z, at which point it becomes horizontal. The situation here has wide applicability as for many environmental resources there will exist mutually exclusive alternative resources that would enable only a slightly lower utility level to be obtained.

A point to be noted here, even though the access component of activity Z has not been discussed, is that there is no reason why the travel or access charge to the less preferred activity may not in fact be considerably greater than for the preferred activity. There is no shortage of examples to illustrate these possibilities. To give just one, when a metropolitan beach become congested local residents will increasingly consider alternative activities such as travelling further along the coast to less congested beach areas.

Implications of the Extensions to the Basic Model

The above analysis cautions us that whenever we have a number of observations lying on what we believe to be a section of the demand curve, we may not assume that the complete demand curve is defined by the continuation of a line or smooth curve through these observation and continuing on to the price axis. For many consumption activities a choke price (horizontal section of the demand curve) will exist and therefore consumer surplus calculations based upon a simple continuous demand curve will significantly overstate the value of the resource.

This conclusion, however, is based upon consideration of individual choice. Since we are generally interested in aggregate evaluations which in turn are often based upon aggregate demand behaviour, we need to consider the whole aggregation question in a little more detail. For reasons already discussed above, if full prices were measured on the price axis then horizontal aggregation may make little sense. Even if we put this difficulty aside there are two types of situation we need to distinguish between. First, suppose that choke prices are evenly distributed across individuals, then these 'indivisibilities' would impact uniformly along an aggregate demand relation and estimates of aggregate surplus based upon observations on a section of the aggregate curve need not lead to an overstatement of a resources 'value'. Suppose instead, however, the choke prices were similar across individuals as might well be the case where individuals have a common ‘next best’ alternative. In this case if aggregate price-quantity observations were obtained involving prices below the ‘common’ choke price range, then the likelihood of overestimation of resource value clearly exists. But this latter scenario is almost exactly the one that underlies the travel cost method of resource evaluation and it is to this we turn our attention.

V. REPEATED CONSUMPTION ACTIVITIES AND THE TRAVEL COST METHOD.

The switch in focus from an activity that is only undertaken once in the period of concern to the situation where activities may be repeated a number of times is not a trivial matter. While the quantity variable in the previous section reflected measures of how much time might be spent in a park or actually fishing when the activity is undertaken only once per period, in the new situation the quantity variable of concern will now reflect something such as how many times an individual might go fishing per year. A consequence of this is that the relevant price variable will also change, for example, from the price of ‘catching a fish’ (once you are at the fishing site) to the full cost of ‘making a fishing trip’.

It can be seen that the issue of mutual exclusivity is one of key importance. If a person goes fishing on a particular lake several times a year it is entirely plausible that the best alternative activity will be the same on each occasion. There is a further interesting question here as to whether repeated activities yield diminishing utility but if we initially consider the possibility that a fishing trip one weekend yields the same utility as the same trip taken again the following weekend, then it is equally plausible that the same choke price will apply each time the activity is undertaken.

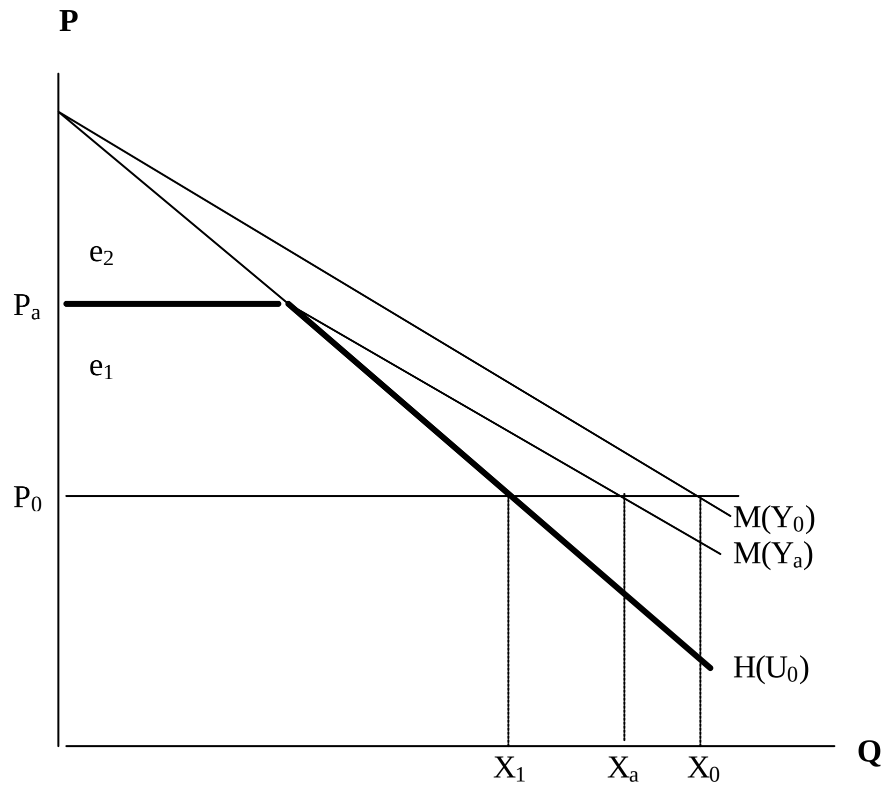

FIGURE 2

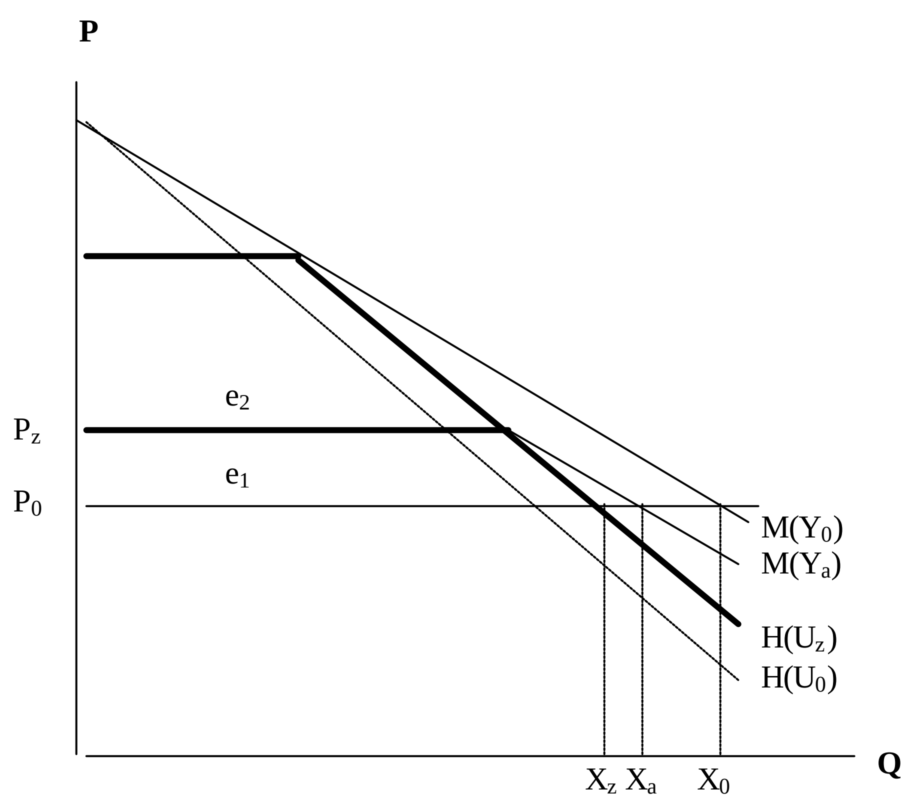

FIGURE 3

To see the relevance of all this to TCM it is useful to first look in slightly more detail at the underlying TCM methodology. There are a number of variations of this approach but the basic idea, as outlined for example in Johansson (1991), is that we can use information regarding the travel costs incurred by different individuals visiting an environmental resource to derive a *distance decay curve.* Such a curve is assumed to have properties that are usefully similar to those of a Marshallian demand curve.

The data required to derive this curve can be obtained by identifying population zones located at different distances to the resource and for each zone obtaining two variables: the number of trips as a proportion of the zones population; the average travel cost per trip from that zone. The set of observations generally lie on a downward sloping locus. Areas to the left of the curve and above a zone's cost line are used in conjunction with zone population data to obtain estimates of the aggregate Marshallian consumer surplus accruing to the population of the zone in question as a consequence of the availability of the resource.

Our earlier considerations immediately caution us to be on our guard. For expositional simplicity we will consider two zones which each contain a single individual, and assume that the relevant compensated demand curves coincidentally lie on the same locus. For a particular individual, assume that each `trip= involves identical access and consumption activities involving the same cost to that individual. The critical additional ingredients to those normally incorporated into TCM, however, are the access charge and exclusivity components discussed above and illustrated in Figures 2 and 3. The modified TCM situation is illustrated below in Figure 4.

Here C_A and C_B are the comprehensive costs per trip for individuals A and B respectively, individual A living more distant and having a higher comprehensive cost per trip. Two other variables are shown, P_A and P_B. These are the 'choke' prices facing individuals A and B, assumed to remain constant for each individual irrespective of how many visits are made per demand period. H(A) and H(B) are the baseline Hicksian demand curves for the two individuals.

According to standard TCM, consumer surpluses for A and B would be measured (r + s) and (r + s + t + u) respectively, when from the discussions of Figures 2 and 3 above, the appropriate measures are simply s and u respectively. Clearly the scenario characterised here is entirely plausible. Suppose individuals A and B are both visiting a particular ski resort and that for both individuals the next best mutually exclusive activity is another ski resort only a short distance from the first one. Figure 4 characterises exactly this type of situation. TCM would grossly overestimate WTP and in general, even if the demand curves of individuals in different zones did coincidentally lie along a common locus, the existence of access charge and exclusivity components in the choice problem preclude any useful association between *distance decay curve* triangles and actual WTPs.

These implications for TCM add to a significant literature in which authors such as Randall (1994) have raised serious questions about the usefulness of the methodology. It is important to understand, however, that the issues analysed above are distinct from a more basic identification problem discussed by Sugden and Williams (1978). This 'more basic' problem arises simply from the fact that in general TCM inferences are drawn on the basis of just only a single observation's data on each individual. Put another way, leaving all other problems aside, the issue here is whether inferences about consumers' surplus may usefully be based upon what is effectively a single price quantity observation for each individual. Note that this is a quite different type of data base from that normally used to estimate market demand curves and which involves, at least in the aggregate, responses by individuals to a range of different prices.

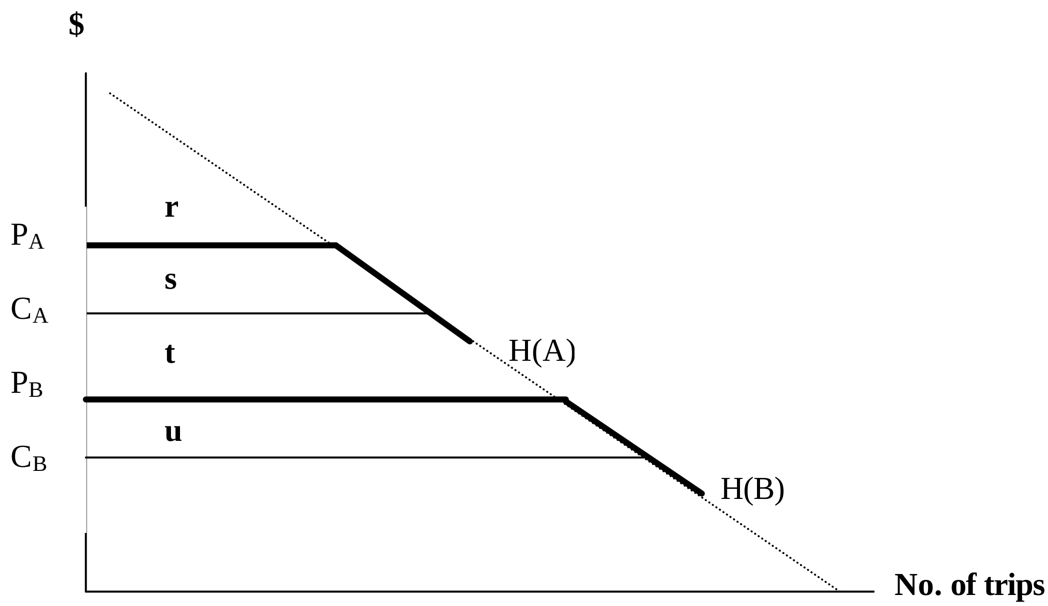

FIGURE 4

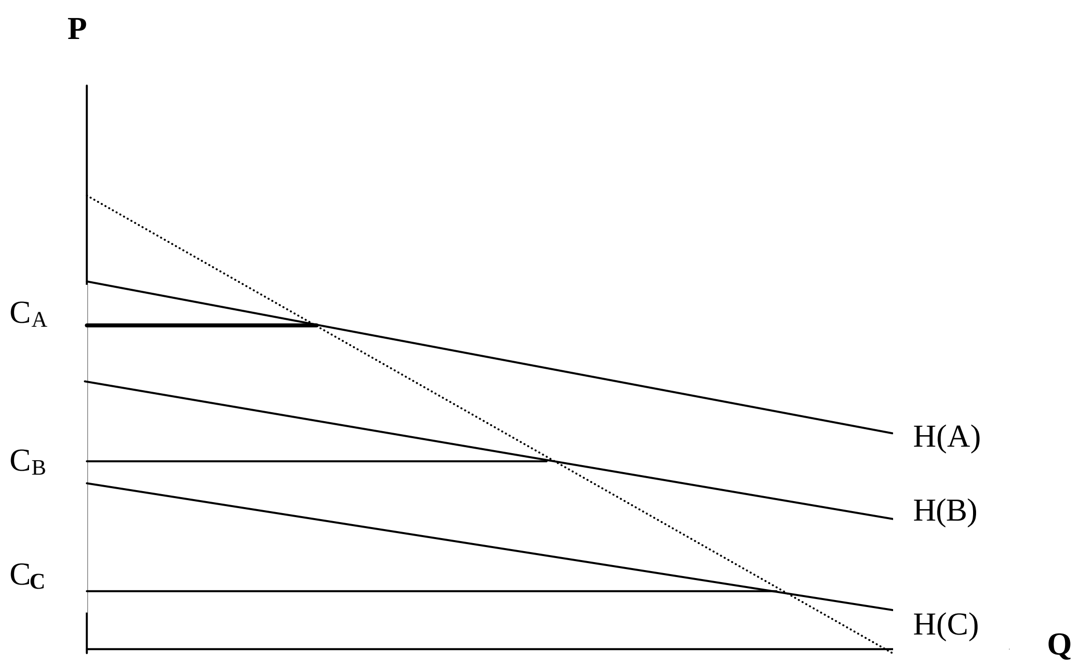

FIGURE 5

Without loss of generality we may again assume that there is only one individual per zone, but that each person makes multiple trips per time period and the cost per trip is constant for each individual (but not across individuals) and is accurately measured. As suggested in the analysis of Sugden and Williams, it is immediately clear is that even if the observations happened to generate a line or curve in price-quantity such as that shown in Figure 5, there are an infinite number of possible demand scenarios consistent with that data, just one of which is illustrated here.

The situation indicated here is one where the individuals facing comprehensive costs C_A, C_B and C_C have (compensated) demand curves H(A), H(B) and H(C), those paying higher "prices" having "higher" demand curves. The consequence in this case is that the 'true' consumer surpluses are far smaller than those estimated under TCM and which derive from the assumption that all individual have essentially the same demand curve.

Of course there are an infinite number of other interpretations consistent with the data including scenarios that would yield higher consumer surplus valuations than those suggested by TCM. Even when the statistical analysis is modified to take into account income and other socio-economic or demographic differences across zones, there is no justification for assuming all differences between individuals who have been purged or even that the TCM approximation reflects a useful expected value. That is, basic identification considerations reinforce the conclusion that *distance decay curves* contain no useful information regarding WTP or WTA. In terms of Figure 5, what our earlier analysis has added is the likelihood that the demand curves H(A), H(B) and H(C) would not be as shown, but discontinuous in the manner of Figure 4. For all of the reasons discussed it is clear that there are major difficulties involved in deriving useful resource valuations from methodologies based upon estimation of demand relationships. Since establishing the value of a resource is a key plank of policy management there seems to be a compelling case for considering a methodology such as CVM which is designed to elicit directly informed on the value of resource consumption activities.

V. CONTINGENT VALUATION METHODOLOGY

Leaving aside the methodological issues discussed in the literature cited above, the question we will address here is whether the empirical approaches typically adopted to generate estimates of WTP or WTA are able to yield information about the marginal measures that are fundamental to natural resource management in general. In fact the attention to marginal cost has tended to be negligible, but a number of authors claim to have derived marginal valuations for particular resources. An influential study here was that by Cameron and James (1987), which claimed that their econometric analysis of data from a sample of recreational fishers in British Columbia yielded marginal values for Chinook and Coho salmon.

Here, as in most CVM studies, the data collected gives single observations on total willingness to pay and activity quantity data for each individual. It should be noted that Carson, Hanemann and Steinberg (1989) did avoid the difficulties that ensue from the “single observation” approach by obtaining hypothetical valuations over both quantity and price variations, but that their lead has not been widely followed. More generally, however, and in the Cameron and James context of multi-attribute activities, for each individual undertaking a particular consumption activity there will be just one observation of various dimensions of the activity likely to affect the value of the activity and associated WTP data. As Sugden and Williams pointed out for the case of TCM, however, a single observation on a function is insufficient to identify anything very useful about the function.

To illustrate what is a more complex identification problem where CVM is used, consider the case where only the quantities of a single attribute *X* impact upon WTP, so that for each individual there is one observation on each of quantity of *X* and WTP. Such a case is illustrated in Figure 6 below where AWTP decreases as X increases, in the same manner as for TCM. This is consistent with recent fisheries research, as in SACES (1997), although Cameron and Jones actually estimated constant AWTP and MTWP values

For expositional purposes the framework used here shows average willingness-to-pay (AWTP) for each individual (rather than WTP) plotted against their consumption level and a linear relationship has been assumed. The question, as for TCM, is which of the infinite number of interpretations of this data that are possible is the correct one.

One approach, which appears to be implicit in quite a lot of applied work, is that by taking into account a wide range of factors that could affect WTP one has already allowed for the factors that cause individual demand curves to differ. On this basis, Figure 6 can be regarded as showing a representative individual's average WTP relationship, all of these other factors held constant. There is always a one-to-one relationship between an individual's (average) WTP function and a Hicksian (compensated) demand curve, but as indicated in Friedman (1962), where linear functions are involved the relationship is particularly simple and well-suited to our purposes. A linear average WTP curve derives from a linear Hicksian demand curve (which is, of course, a marginal WTP curve), the latter showing half the quantity at any given price level. If the data can be viewed as revealing a "representative" AWTP (or WTP) relationship, then, as suggested by Cameron and Jones, "representative" MWTP's may be inferred.

In practice, of course, if the observations could be assumed to be those of representative individual, economic theory would place some restrictions on the specification of the WTP function. In particular if indifference curves over attributes are convex and if 'normality' is assumed then it follows, for example, that WTP functions will be non-linear and that the MTWP for attributes will be an increasing function of income.

Leaving these specification details aside and returning to our illustrative example, however, there is an alternative and arguably more plausible interpretation of the observations in Figure 6 than that given above. Suppose, in fact, there is at least one unaccounted for respect in which the individuals still differ, and hence, so do their demands. To make the analysis more complete, add in a falling (long run) marginal cost curve of the type that empirical evidence, as cited in SACES, says may exist in activities such as fishing. Realistically this relation should be interpreted as reflecting properties of a long-run expected cost curve, which takes into account the inherent uncertainty surrounding the catch generated by a given effort level on any particular day.

Further assume that these individuals are utility-maximising and therefore aim to consume *X* up to the point where marginal WTP is equal to marginal cost, so that what really underlies Figure 6 is what is shown in Figure 7 above. For expositional purposes it has also been assumed that individuals are on both their short-run and long-run marginal costs. For simplicity only three individuals are shown here and they are each assumed to have linear demand curves. It follows by construction that any three individual linear demands curves passing through the points A, B and C would have generated the three observations on what was assumed above to be the average WTP curve, providing they intersect a marginal cost curve at the outputs X_A, X_B and X_C respectively.

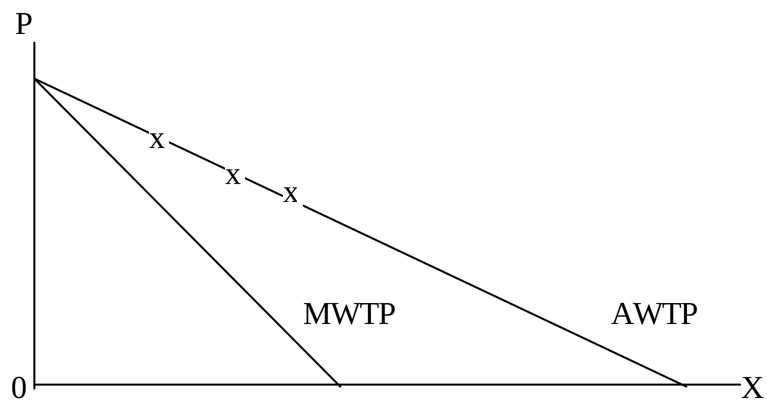

FIGURE 6
AVERAGE AND MARGINAL WTP DATA

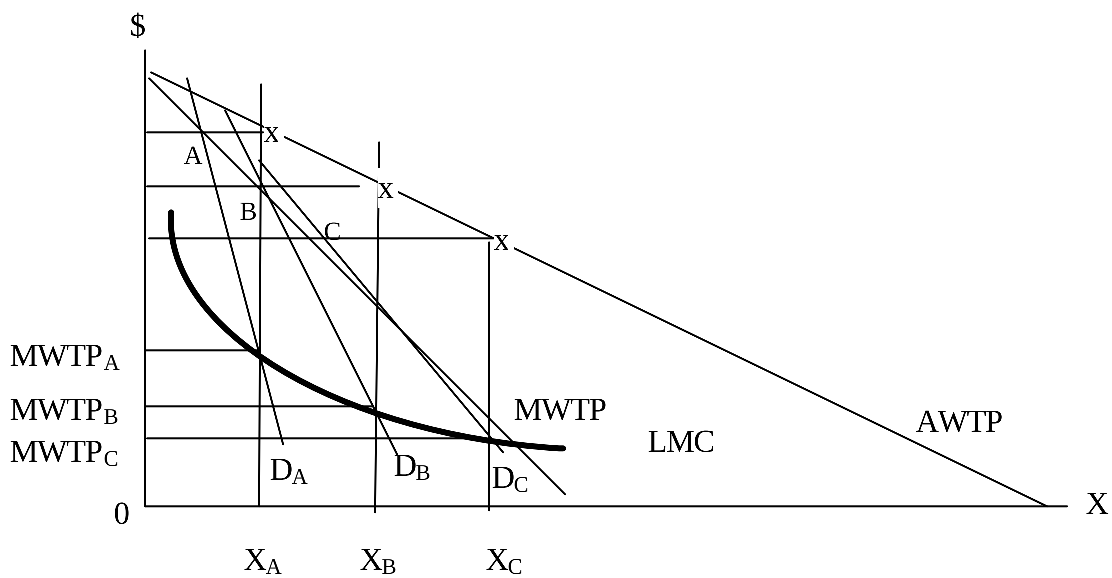

FIGURE 7
DIFFERING DEMANDS GENERATING FIGURE 6 OBSERVATIONS

What is immediately apparent is that the individual MTWP values in the Figure 7 scenario are quite different from those that would have been inferred for the “representative individual” scenario shown in Figure 6. In other words, an infinite number of individual demand curves and associated individual marginal WTP values are consistent with AWTP data such as shown in Figures 6 and 7, and indeed with a great deal of the data collected in contingent valuation exercises.

An interesting and more complex story can be told whereby the stochastic elements affecting the catch on a particular day are modelled as random variations in very short run marginal cost which lead to divergences from conventional short run marginal cost on a day-to-day basis. Since this would not alter the identification issues argued above, these complexities have not been pursued here, other than to note that if individuals’ estimates of their own WTP are based upon expected rather than actual catches then standard ‘errors in variables’ problems arise.

The scenario in Figure 7 is arguably more plausible than the representative individual situation suggested in Figure 6 due to its handling of costs. For the latter to be observed, fundamentally similar individuals are required to face quite different marginal cost conditions which, given competitive behaviour in the supply of inputs to fishing trips, would be unlikely. Figure 7, however, embodies the likelihood of individuals with different demand curves, D_A, D_B and D_C, facing a fundamentally similar long-run marginal cost structure together with the strong probability that there are likely to exist some unmeasurable factors underlying demand differences.

The identification problem has been discussed here only within a simple framework, not within the more relevant multi-variate context. Not surprisingly the problem is exacerbated when additional variables are involved and neither the parameters estimated, nor their relative magnitudes can be assumed to contain useful information regarding individual demand parameters.

Estimation of multivariate functions in the resource consumption area is extremely likely to encounter omitted variable problems, but it is important the problems discussed here are not simply seen as being of that nature. What is strongly suggested here is that one should work from the premise that individual demand curves will differ. A simple test of this proposition need require little more than an additional question being asked regarding WTP at different (hypothetical) attribute levels.

VII. CONCLUSION

Many activities, especially those involving consumption of environmental resources, preclude simultaneous participation in other activities and involve significant time costs of consumption as with costs associated with access to the activity. When demand analysis is extended to take these factors into account major difficulties arise with regard to inferring resource values from data related to demand curves, especially at the aggregate level.

When these sources of ambiguity are added to the range of other problems with travel cost methodology well documented in the literature, it is unclear how one can justify continued use of this approach to obtain estimates of the value of enviromental resources. Indeed, the difficulties in specification and identification of resource demand relations are sufficiently great that the direct approach to valuation underlying contingent valuation methods seems more promising.

Environmental resource management, however, requires information on both total and marginal evaluations associated with resource consumption. As commonly applied, contingent valuation approaches may yield willingness to pay but cannot yield the required marginal measures. To obtain these additional information must be obtained through the questionnaire on survey process.

Relatedly, the ‘differing demand’ story which was used to demonstrate the identification problem arising in contingent valuation studies contains a further ingredient which is of perhaps even greater importance in policy analysis. It reminded us that individual outcomes will be significantly related to the cost conditions faced. If as suggested, individuals tend to consume to the point where price equals marginal cost, given their differing demand schedules, then the usual efficiency conditions will have been satisfied and the absolute and relative magnitudes of their marginal WTPs are of very little interest. If for policy reasons or otherwise these marginal conditions are not to be satisfied then information on marginal private and external costs is at least as necessary as information on WTP, consumers surplus and marginal valuation.

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