Time and the Valuation of Environmental Resources

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Abstract

This paper considers the modeling strategies that have been used to incorporate time in revealed and stated preference methods for valuing environmental resources. After reviewing a subset of the economic models for describing time as an input to household production; time in creating habits and persistence in demand for particular services of environmental resources, and time as offering an opportunity for future consumption, the overview suggests that time has been used as a complement in production or consumption to marketed goods in each of these frameworks. The paper suggests two possible alternatives. This structure along with further restrictions to preferences or technology implies that there are other strategies for using revealed preference data to measure the economic value of changes in environmental quality.

Key Words: time, revealed preference, complementarity

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> "There is no difference between time and any of the three dimensions of space except that our consciousness moves along it"
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> (H.G. Wells, *The Time Machine*, 1895, p. 3)

I. INTRODUCTION

Common sense suggests that people's values for environmental resources would be reflected, in part, by their time allocations.[1] Selecting a place to live or work; taking care of one's self to avoid days lost to illness; or deciding where to go for a fishing or skiing trip are all choices that have implications for how an individual spends his (or her) time.[2] Each decision could be interpreted as a time allocation linked to activities that can also be related to environmental resources. To the extent the time allocation is affected by the amount or quality of these resources, then we have another basis for observing how a person's valuations of these resource features influences behavior.

The links between time and the values of environmental resources do not stop here. Earlier choices can have multiple implications for current decisions. Experience in an activity reflects the accumulation of past decisions to spend time doing it. For example, experienced individuals may have more complete information about substitutes, such as alternative recreation sites (or potential home sites). They may have greater skill in specialized recreational activities (e.g., rock climbing, scuba diving, or white-water rafting).[3] Memories

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1 This analysis focuses on use related values. While it might be argued even nonuse values require some allocation of an individual's time we avoid this issue here. See Farrow and Larson [1995] for a provocative analysis of the link between nonuse values and time devoted to watching major news shows.

2 Monetary measures for people's values are derived from the economic choices. Thus, establishing that decisions about time allocations involve environmental resources suggests that these choices convey information about the values of the associated resources. This basic logic is central to all methods for non-market valuation. For a discussion of the features of economic choices in the context of valuation see Kopp and Smith [1997]. A more general treatment of economic analysis of choice is given in Sen [1997].

3 See Shaw and Jakus [1996] for an analysis of the effects of experience within a random utility model for decisions about the routes taken in rock climbing, Munley and Smith [1976] for experience in white-water rafting, and Leeworthy and Wiley [1996] for a summary of a survey of users of the Florida Keys.

of especially enjoyable past experiences can also influence people's willingness to save money or accumulate vacation time to permit them to undertake these activities in the future.

Of course, time is not simply an index of effort or a measure of the use for an individual's labor endowment.[4] It is also bundled with other attributes that affect people's values. In this role, we usually interpret time as a reference point. Summer and winter at various locations convey expectations about climate. The hours of a day create expectations about the availability of daylight, the temperature, presence of other people, access to specific facilities, or even the likelihood of threats to personal safety.

A comparison of this diverse template of possible interpretations for time with the existing valuation literature suggests that few of these relationships have been seriously considered. The data available for modeling how people are influenced by environmental resources provide one explanation. However, this is not the complete story. Closer examination of the available research suggests that time has been included but the studies involved have simply not discussed the ways in which time was important to people's decisions. Instead one finds that time has been introduced without "fanfare" as a measure of opportunity cost; as a gauge of experience; or as an index for other characteristics.[5] This paper uses a subset of the economic models for describing time's role in producing household services (Becker [1965]); in creating habits that influence future demands for goods and services (Becker and Murphy [1988]); and in providing opportunities for future pleasures (Becker and Mulligan [1997]) to understand, from a somewhat different perspective, the methods used to estimate the values of environmental resources and to propose two new approaches for estimating or calibrating valuation measures.

All of the models I selected to describe time's links to consumer choice were developed by Gary Becker and colleagues. They share a further characteristic that is important to using them in non-market valuation. As developed below, time is introduced as a complement in production or consumption with one or more marketed goods. This characterization is interesting and has implications for the revealed preference methods we can use to measure the value of changes in environmental resources.

Section II outlines the earliest of the Becker models, his household production framework and its role in travel cost recreation demand, and averting behavior models. Section III describes the ways time has been used as an index or proxy for unobserved variables, focusing on the relevant travel cost, hedonic, and contingent valuation applications.

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[4] Mabry [1970] argued over 20 years ago that one could and should distinguish effort (and energy) from time allocated to work. In private correspondence, Dallas Burtraw has suggested that we should consider each person's labor endowment as well as other endowments in formulating the relevant "income" constraint for willingness to pay measures. Both issues are beyond the scope for the issues discussed here but each clearly is relevant to a general discussion of the role of a person's time in measures of economic value.

[5] This is deliberately stated as in an extreme form. Certainly a number of authors have highlighted the role of time as among the constraints to recreation decisions. (see McConnell and Strand [1981]; Smith, Desvousges, and McGivney [1993]; Bockstael, Strand, and Hanemann [1987]; McConnell [1992]; Shaw [1992]; and Larson [1993]). The point is simply to draw attention to the multiple roles time can play in a model.

In Sections IV and V the habit persistence and endogenous time preference models are developed along with the new opportunities they suggest for valuation methods. Because both of these proposals rely on maintained assumptions as alternatives to panel data or time allocations, the last section concludes by considering the relative advantages of each in extending our understanding of time on an equal footing with the other commodity related links to the non-market valuation of environmental resources.

II. TIME IN HOUSEHOLD PRODUCTION FRAMEWORK (HPF)

Over thirty years ago Becker [1965] suggested a reconsideration of consumer choice that proposed we treat each individual as combining market goods and time to produce services (labeled "basic commodities"). These services, and not the goods or the time, contributed to utility. His proposal assumed household technologies were Leontief, so time was a perfect complement to private goods.[6] Subsequent descriptions of the framework have relaxed several limiting assumptions used in that formulation, one of them allows time and goods to be substitutes in production. It is now generally acknowledged that these approaches offer convenient frameworks for describing the general logic of consumer decisions but do not add to the testable restrictions associated with conventional models.

Two non-market valuation methods are most easily developed using this structure -- the travel cost recreation demand model and the averting behavior framework. Below we

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[6] The original structure of Becker's [1965] household production model assumed perfect complementarity. This is readily illustrated with a single example. Let $U(\cdot)$ describe preferences, then the consumer problem of constrained optimization is:

Max: $U = U(Z_1, Z_2)$

Z_i = final service flow (basic commodity)

Subject to:

(a) Production Technology

$$X_{1i} = b_i Z_i \qquad i = 1,2$$

$$X_{2i} = a_i Z_i \qquad i = 1,2$$

$$t_i = c_i Z_i \qquad i = 1,2$$

b_i, a_i, c_i = input requirement coefficients

(b) Time Constraint $\bar{t} = t_w + t_1 + t_2$

t_w = time spent working, assumed exogenous

$\bar{t}$ = total time available in a given time horizon

(c) Budget Constraint

$$Y = w\, t_w + V = P_1(X_{11} + X_{12}) + P_2(X_{21} + X_{22})$$

This can be re-written in a simple form illustrating how the production technology constrained the roles for goods and time (V = exogenous non-wage income).

$$\underset{Z_1,\, Z_2}{MAX} \quad U(Z_1, Z_2) + \lambda \left[(P_1 b_1 + P_2 a_1 + w c_1) Z_1 + (P_1 b_2 + P_2 a_2 + w c_2) Z_2 - w\bar{t} - V \right]$$

$P_1 b_i + P_2 a_i + w c_i$ = time and goods price of Z_i

consider the treatment of time in each, as well as how it has been used to convey the amount of a resource quality change in contingent valuation studies.

A. Travel Cost Models

Travel cost recreation demand models use time in multiple roles. With general acceptance that the distance between a recreation site and an individual's origin point (typically his home) could serve as an implicit price for trips to that recreation site, applications quickly shifted attention to the time costs of travel. These time costs are a larger share of the costs of a trip than the vehicle-related expenditures assigned to distance. In most applications time is a choice variable. It is an exogenous parameter influencing decisions about which recreation sites to visit and how many trips to take. *Ad hoc* rules, scaling wage rates by one-fourth to one-half, are the dominant approaches used to derive an opportunity cost for travel time. While these practices began in the early seventies, current authors maintain that there are a set of plausible assumptions making the practice consistent with theory (see Larson [1993]).

McConnell and Strand [1981] offered the first formal test of this hypothesis by building the assumption that the opportunity costs were a multiple of the wage into the HPF framework. Their analysis implicitly assumed that an individual's time constraint could be combined with the budget constraint. As a result, the site demand function included two terms for travel costs -- the distance and time components. The time cost assumed opportunity costs were a multiple, k, of the wage rate, w, (e.g., k·w). This formulation implied that if both vehicle related distance costs (together with any entry fees) and the time costs of a trip had the same effect on demand, then the estimated parameters of the demand model identified estimates of the multiplier converting the wage to the opportunity cost of time.[7] Smith, Desvousges, and McGivney [1983] argued that one should expect k to be a

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[7] The three equations below illustrate the logic. The first equation is the site demand (with Q generally measured as trips to the recreation site) with the tc the vehicle related and entrance fee components of cost and $kw\bar{t}$ the time costs of travel, treated as the product of the appropriate fraction, k, of the wage, w, (to reflect the opportunity costs of travel) and the round trip travel time, $\bar{t}$.

$$Q = a_1 + a_1(tc + kw\bar{t}) + a_2 y + a_3 p_s$$

where: y = income

p_s = price of substitutes

with $a_1 < 0$, $a_2 > 0$

$$Q = a_0 + a_1 tc + \bar{a}_1 w\bar{t} + a_2 y + a_3 p_s$$

$$\hat{k} = \frac{\hat{\bar{a}}_1}{\hat{a}_1}$$

The first equation acknowledges that k is not observed and must be estimated. Therefore it is embedded in the parameters $\bar{a}_1$, If travel time were measured separately from distance, this equation enters the total costs of travel time scaled by the wage rate as a determinant of the trip demand. The parameter, $\bar{a}_1$, then implicitly reflects the assumed adjustments to the wage as the opportunity cost, as suggested in the third.

function of the parameters to the choice process.[8] Nonetheless, this critique did not offer direct guidance for alternatives and instead suggested sticking with the wage rate as the opportunity cost for time.[9]

Bockstael, Strand, and Hanemann's [1987] later extension used differences in an individual's time constraints to account for some of the heterogeneity in their behavior. Piece-wise linear budget constraints, (reflecting different wage rates for full and part-time work), implied different opportunity costs of time for individuals in different circumstances, depending on their ability to exercise discretion in their time allocations and on the alternative uses for time. The types of time in all of these models are defined through the constraints to consumer choice. Time was linked to arguments in preferences (e.g., trips to sites as measures of usage) only in the sense that trips reflect the use of one's time endowment. The relative desirability of one "type of time" in comparison to another, apart from its effect through the budget constraint, is not addressed.

Wilman [1980] first proposed distinguishing a "scarcity value" for on-site time and a "commodity value" of time by treating time as both a constraint and as a choice variable in recreation demand models.[10] However, her framework was an arbitrary allocation of costs. McConnell's [1992] recent framework follows this lead and offers a consistent treatment of time as both a component of the constraints to recreation trips and as an element influencing the utility derived from them. His formulation implies a nonlinear budget constraint with both trips and time-on-site per trip treated as endogenous variables. With sufficiently concave preferences, reflecting how each individual makes tradeoffs between on-site time per trip and trips, interior solutions are possible. On-site-time and trips are recognized as joint weak complements in that neither contributes to individual well-being without the other.[11] This assumption together with the nonlinear budget constraint allows the economic value of recreation trips to be measured using only knowledge of the site demand. On site time's

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8 This was especially true when people faced multiple time constraints for "types of time."

9 As noted above, Larson [1993] comes to a similar conclusion for some different reasons. He uses a separable specification that allows two stage budgeting, assumes a fixed labor supply and does not deal with the piece-wise linear budget constraint. He does suggest that to the extent feasible, the wage should be adjusted for income taxes. While this proposal is certainly reasonable, the practical dimension of implementing it are daunting. A household's income tax rate is itself the result of a set of behavioral decisions that affect the mix of deductions available. Some of these represent factors that arguably also would influence the recreation demand (see McConnell [1990] or Parsons [1991]), so the central question is whether such adjustment would add more noise than information.

10 De Serpa [1971] and Cesario [1976] argued that such a distinction was meaningful before Wilman's paper. Smith, Desvousges, and McGivney [1983] outline the reasons why Wilman's proposed definitions of commodity and scarcity values of time are arbitrary.

11 This second dimension of the model also precludes a corner solution in one of the two variables. When either trips or on-site time is zero, then the other must be as well. See Mäler [1974] for the first formal discussion of weak complementarity. To simplify matters, he does ignore the labor/leisure choice implicit in the Bockstael et all. [1987] framework.

economic value is captured through the demand for trips, because every trip is assumed to be the same length.[12]

Most of the recent literature modeling recreation demand with random utility models assumes site selections are made for each choice occasion independently. Choice occasions are single days or weekends. Because this structure is held constant across individuals, neither past history nor future prospects are relevant for models of site decisions. As a result little attention is given to time constraints. Of course, this does not limit their effects on actual behavior and we can see these impacts in at least two ways. First, they imply the budget constraint must be re-defined so it is consistent with the time horizon for choices taking place on independent occasions. Simple RUM analyses avoid this by assuming constant marginal utility of income. Once the conditional indirect utility functions are specified to be nonlinear in income, this issue cannot be "sidestepped". As a rule we have little information to decide how to allocate income. Second, and equally important, these independent choices must be linked to seasonal site demands. Of course, the total seasonal demand could be specified as the aggregate of a set of independent decisions. However, a number of factors make adopting this as the only approach to connect site choice with total use seem implausible. Diminishing marginal value of the trips and/or a desire for variety

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[12] McConnell argues that this model parallels the earlier Bockstael-McConnell [1983] analysis of household production models where, as a rule, the demands for household produced services did not admit Marshallian demands (except in special cases of nonjoint, constant returns to scale household technologies). This characterization does not match the current model. In this case there is a Marshallian demand for on-site time but it is incomplete as a welfare indicator. If one considers total on-site time across trips instead of time per trip this would be a consistent Marshallian welfare measure and equivalent to what is provided by the demand for trips. This follows directly from applying the envelope conditions to the McConnell model. Let $V(p_x, p_t, p_z, y)$ be the indirect utility function with y income, p_x the price of a trip and p_t the cost of on-site time. x=trips and t=on-site time per trip. Then by the envelope condition where ($y = x(p_x + p_t \cdot t) + p_z \cdot z$ with z a numeraire good) we have:

$$x = -\frac{V_{p_x}}{V_y}$$

and

$$t = \frac{V_{p_t}}{V_{p_x}}$$

Using these two relationships we can show that the following two conditions convey the relevant welfare measures, whether express as a count of homogeneous trips or an index of total across trips on-site time.

$$-V_y \cdot x = V_{p_x}$$
$$-V_y \cdot x \cdot t = V_{p_t}$$

This formulation is consistent with applications that separate the modeling of trips of different length (such as Brown and Mendelsohn [1984]). It does not deal with recreationists whose trips are mixes of different lengths in a plausible way because the models treat these as independent and therefore do not consider the linkages created by time constraints within a season. The Parsons and Wilson [1997] model for incidental and joint consumption as an influence on the conventional travel cost demand framework is very close to the same specification. In their description, incidental consumption is not undertaken unless the trip is taken. While they discuss the adaptation to their model for separate choice of incidental consumption, welfare measurement for this case is not developed completely. Thus, what is presented closely parallels McConnell's two way weak complementarity.

(once some sites had been selected) could be argued to have an effect on the pattern of seasonal outcomes across sites and, therefore, the magnitude of the aggregate demand for trips. The issues involved in developing this link were first identified by Bockstael, Hanemann, and Kling [1987] and have been the subject of considerable recent research with a variety of approximate solutions proposed. As Shonkwiler and Shaw [1997] indicate, the approaches can be distinguished by the price indexes each maintains should be used to relate site choice with second stage seasonal demand functions defined to explain total trips.[13] While this process implies both time allocations (to a number of recreation trips) and site choices, there is no specific treatment of time constraints in any of the models proposed. Instead time is treated as a parameter influencing the travel costs to visit each site.

B. Averting Behavior Models

Time enters the averting behavior framework largely as an input to the production of activities that reduce the effects of negative externalities. With sufficient maintained assumptions, the framework can be used to develop an implicit price for environmental resource. The two assumptions usually meeting this requirement are: (a) time as a perfect substitute for the resource (Mäler [1985]) or (b) time as an essential input in a household function that also includes the environmental resource (Bockstael and McConnell [1983]). In the first case the expenditures on time serve as a price for the environmental resource, while the second offers an alternative explanation for weak complementarity.

There have been few direct applications of either approach in practice. Stories explaining empirical models abound, but these are generally not used in efforts to measure the value of amenities.[14] The only direct use of time allocations in estimating willingness to pay for reducing an environmental risk is Agee and Crocker's [1994, 1996] use of parental time in the treatment of children for body lead burdens. Both studies consider the same decision about the treatment of the same sample of children. The more recent paper directly illustrated the use of time as a required input to production of the therapy. The time costs of one parent are treated as the price in a random utility model, implicitly assuming it is a perfect

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[13] In a short comment on the Hausman, Leonard, McFadden approach (Smith [1996]) I have argued their approach is not a theoretically consistent link, as they claim. This follows because the quantity index used does not match the price index. The same criticism holds for the implied models of the other approaches.

[14] Two example from my own work illustrate how empirical analysis becomes largely "stories". In an analysis of the value of reducing the risks of exposure to hazardous substances, Bill Desvousges and I (Smith and Desvousges [1986]) considered the act of attending public meetings about water contamination, an example of behavior motivated by the values for risk reductions. This is an indicator of concern and willingness to devote time to an issue but making the connection to a willingness to pay estimate would be difficult with the information available. Smith et al. [1993] estimated a household production function for sport fishing with time spent fishing treated as an input to the process. The linear in independent variables model implicitly assumes that this time was a perfect substitute for estimates of the pollution loadings also included in the model. This form was selected as a simplification for estimate, not as part of an effort to estimate from the time allocations the value of reducing pollution.

complement to other inputs in the production process (and that the costs of these are largely covered by insurance).[15]

C. Contingent Valuation

It should be possible to observe all the roles for time in relation to environmental resources through contingent valuation (CV) methods. With control over how the object of choice is presented to people, this approach allows the analyst to vary features that will isolate the tradeoffs necessary to provide these descriptions. However, the actual research record does not match this conjecture. Time as a measure of amount of something amenity consumed, as a factor in inter-temporal substitution, and as an index of other characteristics are all represented. Unfortunately, the studies involved did not intend to consider these issues separately from a specific resource change. Moreover, there appear to be few examples that permit the role of time to be separated from the changes in the environmental resources involved.

One case where some attempts at separating the two effects were possible arises from studies valuing reductions in pollution that impacts visibility at prominent recreation sites, such as those in the western U.S. (e.g., the Grand Canyon, Mesa Verde, etc.).[16] Initial comparisons of the CV estimates of the willingness to pay for visibility improvements suggested a wide discrepancy in findings for changes in visibility conditions that were approximately comparable and specified to take place with the same resource (i.e., the Grand Canyon).[17] Photos with the visibility changes involved were used in all the studies, so differences could not be attributed to respondents' ability to "visualize" the impacts. The Smith and Osborne [1996] re-analysis of these results suggests that most of the difference can be attributed to time related components of each study's explanation of the change. That is, those studies finding larger WTP values for avoiding deterioration in visibility had descriptions for policies explaining that more times of the year would be subject to visibility impairment and therefore users would have a greater likelihood of encountering the loss. Moreover, the timing of the impacts was not limited to period of low visitation.

By contrast, the studies with extremely small estimates for the WTP to avoid the visibility reduction had described the timing in a very different way. They suggested the reduced visibility conditions would arise a few days in a year. The specific study using this description also suggested that these episodes would be during the winter. Thus, both the amount and the timing of the change in the amenity were represented in these CV studies'

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[15] The Agee and Crocker [1994] paper does not make this assumption and defines the full price as treatment costs plus time costs net of insurance payments. Comparison of the mean and standard deviations for this variable between the two papers suggests that they are identical. Insurance must cover all the treatment costs. It would seem that all households in the sample had insurance.

[16] Applications to value visibility changes at the Grand Canyon were especially controversial because of an EPA rule that increased the stringency of emission limits at a nearby power plant.

[17] See Levy et al. [1995] for a discussion. In some contexts these discrepancies were used to question the validity of the CV method.

descriptions of the commodity. With the exception of this comparison across studies, for the most part, the focus of each study was on valuing changes in visibility. The effects of time as another measure of amount of resource change available (e.g., the relative frequency of undesirable conditions) and as an index of the timing of the changes were often constant within the scenarios described in each study. As a result they were not cited as a potential reason for the different results until the results were compared systematically across each of the studies.

Another example of a role for time in a CV study arises in the Southern California Bight study's scope test (see Carson et al. [1994, 1997]). Here, time is introduced explicitly as part of a plan to accelerate the recovery of a set of injured resources. This approach bundles the timing of the actions with the changes to the affected resources. This composite commodity was developed as part of a natural resource damage case and was intended to describe actual conditions. Scope was tested by varying the object of choice in two accelerated recovery plans. Both the timing of natural recovery and the number of affected species are different in the descriptions of plans for accelerated recovery that are offered to the survey respondents. These differences in time between natural and accelerated recovery and in the number of affected species define the base and scope "commodities." In principle, a format like this one would allow measuring inter-temporal rates of time preference provided the design isolated each effect. However, in this application, the specified changes did not permit the individual factors to be separated.[18]

III. TIME AS A PROXY FOR INFORMATION OR FOR SITES' CHARACTERISTICS

There is considerable diversity in the information available *ex post* about the temporal distribution of environmental quality. In the case of ambient air quality, for example, the national regulation of criteria air pollutants have generated an extensive database through the monitoring system used to isolate areas that are not in compliance. For water quality, the regulatory process is different and does not require ambient monitoring of conditions so the spatial and temporal record is more incomplete. Information about the temporal and spatial distributions of other environmental amenities is more incomplete.

Under these circumstances, the timing of consumption, of a home sale or the amount of elapsed time between some announcement and a behavioral action is used as a proxy for the *ex ante* site conditions or extent of information available to individuals observed making particular choices. Travel cost, hedonic, and contingent valuation methods have all used this feature in valuing related amenities.

A. Travel Cost Models

The two most detailed applications using time to convey site attributes have been RUM frameworks. In both cases time has been used as a constraint and as a measure of the amount of recreation consumed in their descriptions of recreational site choices. The Hanemann, Carson,

[18] Carson et al. [1994] do report finding some responsiveness to changes in the time horizon for recovery without action as part of the preliminary research to design the questionnaire.

Gum, and Mitchell [1987] nested RUM model for sport fishing in South Central Alaska was the first of these efforts. Figure 1 reproduces their description of the nested structure of the model with decisions about the number of trips taken per week linked to indexes of leisure time, ownership of recreational equipment, experience, the length of past trips, and the weather conditions. The framework decomposes the decision process into four stages: to go fishing each week (with each week independent of past choices or future plans); to select a target species class conditional on the outcome of the first decision (i.e. a decision to take at least one trip); to decide more specifically on a member within the class; and then, conditional on the earlier choices to select a site. Time's role in their model is focused largely in the decision to take a trip each week (i.e. the top of the nested structure illustrated in the figure). Measures of time constraints, whether the week involved includes the July 4th holiday, and a measure of the average length (in days) of the trips taken during the season being modeled were the primary time-related variables in the model used to describe the number of trips taken (including the case of no trips) in a specific week of the season. The inclusive values for the modeling of decisions about decisions associated with targeting aggregates of the available fish species are distinguished by week of the season, weekly temperature, and a measure of experience (and skill) are also included. The "constraint related" measures of time availability were generally significant, with those having more leisure time likely to take more trips and the July 4th holiday increasing trips. There did appear to be a significant substitution between numbers of trips and the average length. Decisions were also affected by skill, timing and weather conditions.

More recently, Desvousges and Waters [1995] followed a similar strategy by dividing the decision process into fishing trips per week, selection of a river or lake conditional on this choice, and then a site/duration pair conditional on the first two choices. In this model time is introduced at several stages in the decision process. A qualitative variable indicating flexibility in decisions about work versus leisure is a significant factor in the top level decisions about taking trips, and this is distinguished for one versus two or more trips in a week. However duration is treated as an influence on site choices (conditional on the sites being rivers or lakes) at the lowest nest in the process and is also a significant factor. While neither of these two models consistently links the constraints on time to their specifications for the indirect utility function, they do offer the most detailed accounting of a decision structure that takes account of the temporal pattern of trips, the site selection choices, and the decision about how much time-on-site. Both required panel data on individual recreationists over at least one season to be estimated.[19]

B. Hedonic Models

The hedonic price function is defined as an equilibrium relationship in a static setting. Issues of time have focused largely on: (a) the extent to which the transactions used to estimate the hedonic function can be assumed to be derived from market participants with the

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[19] Kaoru's [1995] nested RUM also considered two distinct roles for time--the trip itself and the time on site per trip.

same information, and (b) the role of time as an index of typical environmental conditions at a location.[20] The first of these relates to the roles an analyst hypothesizes will be associated with learning and experience and is usually associated with undesirable site attributes. In effect, the analyst must consider when the site characteristic of interest was known by market participants in relationship to the dates of the sales. This is especially important if the sample pools sales across several years. Table 1 (below) summarizes a sample of the recent evidence.

The overall conclusion following from this summary is that the effects of disamenities on housing values are unstable immediately after the initial information about a site specific disamenity has become available. This has been confirmed using models estimated separately in each of a set of years (i.e., Randall [1993], Kiel [1995]) and with pooled models (where transactions over several years compose one sample). In the latter, the specifications maintain a specific role for disparities in information by including time specific quantitative variables with sales over several years spanning the information changes (Schulze et al. [1986], Michaels and Smith [1990], Gayer et al. [1997a]). The most recent study (Gayer et al. [1997a]) distinguishes the effect of distance to the closest Superfund site, a count of non-NPL, RCRA, and PCS water pollution sites with distance zones near a property, and a technical lifetime cancer risk estimate based on EPA's risk assessment methods. This study and the earlier Randall [1993] study include measures of the information from local newspapers about either specific sites or Superfund issues in general. Both cases indicate that timing of the announcement has an effect even when the news variable is included.

Unfortunately, these models do not provide sufficient information to separate the effects of time and other proxy measures that are used to describe how the experience with risk related information influences people's values for risk reductions. In a reduced form analysis, focusing on a subset of the large data set used in their hedonic study, Gayer et al. [1997a] considered the houses with repeat rates information to investigate how people responded to risk information. By maintaining the assumption that prices should decrease with undesirable information, they use the price changes due to new information to infer how buyers use any new information that becomes available between sales. They conclude that buyers did respond consistently to the risk information-- apparently lowering risk perceptions. Because their model embeds a detailed risk perception framework as well as a hypothesized perceived risk/housing value relationship into the maintained hypothesis supporting this conclusion, it is not a direct test of the role of time and associated learning for how an individual would value of risk reductions.[21]

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[20] There has been some discussion of the effects of time a house spends on the market as a factor in influencing the relationship between posted and sale prices for homes. However, most of the modern hedonic studies used in environmental valuation efforts have been based on sale prices rather than assessed values or posted prices. As a result, considerations of an adjustment model cannot be addressed with the information available.

[21] It is also limited by the fact that different individuals are involved in a repeat sales study. That is, the original buyer is now the seller in the second sale. At the margin we would expect the marginal reservation price to equal the marginal offer price. This does not assure it will accurately reflect updated risk perceptions for the two different agents involved.

Table 1: A Sample of Hedonic Studies with Results on Learning about Site Specific Characteristics

Study	Dates of Sales	Location	Characteristic and Methods of Analysis	Results
McClelland, Schulze, and Hurd [1990] and Schulze et al. [1986]	August 1983 - November 1985	Los Angeles, CA	Proximity to Landfill with hazardous substances operated from 1948 to 1984; used property value (sales price) for 181 houses in communities adjacent to site; used sale price in relation to date of information about site	Found evidence of instability in hedonic model immediately following announcement of negative information about site
Michaels and Smith [1990]	1977 - 1981	Boston, MA	Distance to NPL hazard-ous waste sites; investigated effects of sub-markets; distance measure with multiple sites and timing of sale in relation to discovery of site; for timing measure distinguish sales 6 months after discovery from sales more than six months after discovery	Timing affects influence of minimum distance for overall hedonic and for selected sub-markets
Randall [1993]	1985 - 1990	Fayetteville, NC	Separate hedonic models by year with sales price and complete records; considered distance to each of two NLP sites; both listed in 1987	Distance initially a negative influence on price (except for one site in one year) prior to announce-ment; becomes positive influence by two years after announcement as NPL sites
Kiel [1995]	January 1975 - December 1992	Woburn, MA	Distance to two controversial Superfund sites	Effect of distance on sales prices changes over time; becoming significant when odors from one site become noticed; implied marginal values increase. In each year after sties named Superfund sites (1982-1984) values of distance increase (estimates per mile are: 1985-88 3,819 1989-91 4,077 1992 6,468 per mile

Table 1: A Sample of Hedonic Studies with Results on Learning about Site Specific Characteristics (continued)

Study	Dates of Sales	Location	Characteristic and Methods of Analysis	Results
Gayer, Hamilton, and Viscusi [1997a]	January 1988 - December 1993	Grand Rapids, Walker, Wyoming, Kendwood, and Grandville, Michigan	Detailed information on 6 of 7 Superfund sites permits evaluation of estimates of risk, distance, and information variables	Separate statistically significant effects of dummy variables for sales before EPA information from Remedial Investigation (RI) of closest site is available. Estimated risk has larger effect before information from EPA RI confirming instability noted in earlier studies with distance

The second area where time has been incorporated into hedonic models is as an index of site-specific conditions. Under this interpretation, the measures of inter-temporal substitution developed from rental rates for beach properties (Smith and Palmquist [1994]) reflect the differences in seasonal conditions in pre and post versus the peak season. As with the case of the time/experience connection, these are reduced form models. One must include specific hypotheses about whether the effects of other site and housing characteristics in the hedonic price function change in order to use the seasonal price differences for the same house to estimate temporal substitution. The Smith and Palmquist study did find evidence that inter-temporal substitution was influenced by the site specific amenities, but it is conditioned by this maintained assumption.

Without information sufficient to isolate consumer preferences, hedonic models can account for time either as a measure for experience (or knowledge) or as an index of specific characteristics. They do not provide unambiguous estimates of how these time effects are linked to people's willingness to pay for amenities or risk reductions.

C. Contingent Valuation

Three recent CV studies provide illustrations of how temporal differences in a resource's services (described in terms of parts of a year) have been introduced into the design of the object of choice. All involve management decisions for hydro-electric facilities with tradeoffs between lake levels and flow conditions impacting both the electricity generated and the down-stream conditions. The first by Cordell and Bergstrom [1993] presented four sets of views of lake conditions at different times in the recreational season to display the links between hydro-electric generation policies and water levels. These were to be compared with scenes showing lake levels that would arise in the same time periods of the season for a baseline pattern of hydro-electric generation. The sample population was assumed to be recreationists so an intercept example was constructed for the lakes involved in the study. Each respondent was asked about all three of the hydro-electric generation/lake level policies, distinguished with the scenes corresponding to higher lake levels for approximately one, two, and three months. The estimates of WTP conformed to *a priori* expectations with greater payments for longer periods of higher lake levels at each of the lakes considered. However, because respondents saw all the cases we must assume that they compared than in formulating their answers (it was a survey that was mailed back after the initial intercept contact). Moreover, the design of the quality issues linked the changes in lake levels and timing so we cannot distinguish separate effects.

A second study by Welsh et al. [1995] considered seven different flow rates as well as other changes that were presented to <u>independent</u> groups of respondents in a CV study intended to estimate the nature of these respondents' nonuse values the changes in the operations of the Glen Canyon dam. The proposed changes would alter daily fluctuations in the river levels and have impacts on other environmental resources in the Grand Canyon. Background material provided with the survey explained the history of the dam's effect on the ecosystem over the 30 years since it was built as well as the nature of the seasonal and daily variations in water flows and their impacts on resources in the Canyon.[22] While the results do indicate consistently higher values (but not necessarily significant differences) with less fluctuations in flow, the design does not allow the study to consider specific changes in timing of the various flow patterns evaluated.

Finally, the last example of this group of studies by Cameron et al. [1996] combines actual and contingent behavior to evaluate policies impacting lake levels for the dams along the Columbia River. The model is estimated combining three sets of information for each of three lakes: actual monthly usage in season (for the months of May through August) and average "rest of the year" by a sample of recreationists for each lake and the average usage expected for each of two contingent behavior scenarios specifying the water levels under different sets of operating conditions.[23] All responses are assumed to arise from the same demand structure. Modeling adjustments to distinguish monthly and annual usage focused on the error terms. All of the temporal effects were assumed to be captured through the variations in the water level measures as shifts to linear demand models. With this study, it is hard to judge the extent to which the data would have permitted a more detailed treatment of temporal effects. In principle, the quality differences over time would offer the prospect for considering the effects of the temporal changes on the pattern of recreation.[24]

Overall, one would probably conclude that time has been an effective instrument for site characteristics and keeping track of "timing" in relation to choices can serve as a proxy for differences in information relevant to those choices. Unfortunately, this conclusion is largely the result of agreement between the signs of estimated parameters for the time variables and the a priori expectation underlying each interpretation. There have been no attempts to evaluate whether the often unmeasured variable (which with forethought might have been recorded) would yield to the same qualitative effects.[25]

IV. ACCUMULATED TIME, EXPERIENCE, AND ACQUIRED TASTES

The Becker-Murphy [1988] rational addiction framework can be used to consider the role of experience and habits in explaining how an individual's preferences are assumed to include the current consumption of the good, x_t, and a "stock effect", S_t, that is assumed to be due to experience or habits. This stock variable is usually represented as an accumulation of

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[22] Boyle et al. [1993] considered the effects of flow conditions for white-water rafting in the same area, but did not consider timing effects in the same detail as the Welsh et al. study.

[23] Average annual usage was computed from the actual monthly trips and from the contingent behavior responses. By stacking the actual monthly responses with the two average monthly responses for contingent behavior and the actual rest of the year, the sample is expanded. Heteroscedasticity, but not cross time period correlation appear to have been accounted for the average of actual monthly use is not included because it is redundant information.

[24] Most of the analysis was focused on correcting for a diverse array of selection effects and adjusting for the participation decision (in a single hurdle framework).

[25] Of course, one could also ask people about what they know before housing decisions or to report what they knew. Such efforts have not been considered because the responses to these types of questions are considered poor measures of the actual information set.

past consumption decisions involving x_t. In the context of most environmental applications the stock effect often reflects experience, skill, and knowledge of the activities involved rather than a habit. What is important about the framework is the connection between decisions over time. A consumer is described as solving a dynamic optimization problem where preferences are assumed to be the discounted value of time separable utilities, subject to budget constraints that allow for re-allocation of income through time. Ultimately expenditures and income must balance over a lifetime with appropriate adjustment for any substitutions made through time (i.e., reflecting the appropriate interest rates). If the experience related stock variable follows their format, accumulating with usage of the time-linked good, and is also subject to a simple form depreciation, then a steady state consumption profile (i.e., $dS/dt = 0$) implies current consumption is a fixed multiple of the past stock (i.e., $x_t = aS_t$, with a = the rate of decay of the effects of past consumption of x_t). The primary models using behavioral description of how past consumption influenced current behavior follow the early suggestion of Davidson, Adams and Seneca [1966] and primarily involve recreation.[26] As a result, the discussion of past research will be limited to these travel cost applications.

A. Travel Cost Models

Travel cost models have considered the effects of experience but only McConnell et al. [1990] and Adamowicz [1994] have developed formal treatments similar to the habit/addiction models associated with Becker and Murphy [1988]. Most other applications have confined their attention to incorporating the years of experience as a determinant of current recreation demand or site choice. Experience generally leads to greater demand and willingness to pay.

The record with the more formal models is not as positive. For example, the McConnell et al. tests of the habit persistence model did not provide support for the dynamic framework associated with the addiction model. Adamowicz's [1994] reformulation of a RUM framework in terms of dynamic prices does suggest habit persistence for most sites.[27] Unfortunately, his results rest with the ability to distinguish current and "future" prices for the recreation sites. In contrast to market goods, there is not a clear basis for expecting how these implicit prices would change independent of each individual recreationists' decisions.

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[26] The potential importance of this linkage was first emphasized by Davidson, Adams, and Seneca [1966] who described "learning-by-doing" as a public good externality where:

> "…participation in and enjoyment of water recreational activities by the present generation will stimulate future demand without diminishing the supply presently available." (p. 186).

The primary focus of their discussion was on how access to recreational facilities provided opportunities to learn and, in turn, "created" future demand. This new demand was a by-product of past supply being available for use and did not preclude future use of the facilities.

[27] Adamowicz reformulates the preference function in terms of stock measures for consumption, so prices consider the current and anticipated future prices as: $\hat{P}_{it} = P_{it} - d_i P_{it+1}$ with d_i = parameter distinguishes habit persistence from variety seeking behavior.

Because the ability to distinguish habit persistence from variety seeking relies on the exogenous determination of these prices (and Adamowicz does not describe how these travel costs were distinguished over time), it is hard to judge whether the specific results offer strong support for the model.[28]

If we consider another implication of the habit persistence-experience model and compare different individuals we find a more positive record. Comparisons of experienced and novice recreationists, especially where skill is important to the activity, do suggest greater demand (sometimes different types of demand) as well as greater willingness to pay for enhanced quality. Shaw and Jakus [1996], for example, report on an interesting study of rock climbing that indicates general participation, site choice, and the amount of use were influenced by the recreationists' ability. Some years earlier Munley and Smith [1976] found that proxies for willingness to pay for white-water rafting (i.e., willingness to travel) were affected by past experience and skill, but that the effect did not increase indefinitely.[29]

As a rule, the conclusions derived from these analyses (as well as the evaluations of the timing of recreation decisions such as those discussed in the previous section) have been calls for "more and better data." The Becker-Murphy [1988] models seem to offer an alternative strategy that uses the theory linking current consumption to the stock variables in the steady state and relies on other assumptions frequently used in non-market valuation. This proposal is developed in the next subsection.

B. Using Experience Effects to Value Environmental Resources

Consider adding one non-market environmental resource, in addition to x_t and S_t, to the Becker-Murphy model and assume that preferences are separable in the numeraire good, z_t, as in equation (1).

$$U_t = U(x_t, S_t, q_t) + h(z_t) \tag{1}$$

If x_t and q_t are assumed to be weak complements, so $\frac{\partial U}{\partial q_t} = 0$ when $x_t = 0$, then under steady state conditions S_t and q_t are weak complements as well. One simplistic way of characterizing this effect of the steady state condition is that x_t and S_t are comparable to McConnell's [1992] joint weak complements. That is when $S_t=0$ we expect $x_t=0$ and vice versa. While this is a steady state condition, we can use it to exploit cases involving inexperienced and experienced recreationists.[30]

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[28] Equally important he acknowledges that his framework makes a number of simplifying assumptions. These include the use of the basic logic of an intensive margin framework (i.e., marginal rates of substitution equal relative prices) to motivate his RUM formulation and an iterative estimation scheme that does not assure unbiased estimates of the variances for the parameters that distinguish habits persistence from variety seeking behavior.

[29] Below I will argue these types of effects can be used in testing the Becker-Murphy addiction model.

[30] Closer examination of this dimension of preference heterogeneity would seem to be warranted given the positive empirical reward referred to earlier in the discussion of effects to distinguish experienced and inexperienced recreationists.

To the extent we can identify activities that are perfect substitutes for the effects of the stock of experience on preferences, then the demands for these activities should also yield information about the value of changes in environmental quality. Using a Becker's simplification of the Becker-Murphy model with a threshold consumption view for experience, and adapting it to introduce environmental quality we have equation (2) for preference relationships:

$$U = V(b(q_t) \cdot x_t - \theta\,\alpha\,S_t) \tag{2}$$

A permanent change in x_t along a steady state consumption path (with wealth compensation and zero rate of time preference) suggests that the slope of the dynamic equivalent of the Hicksian demand with respect to price will be affected by quality as:

$$\frac{dx_t}{dp_x} \approx \frac{MU_w}{V'' \cdot (b(q_t) - \theta\,)^2} \tag{3}$$

where MU_w = Marginal utility of exogenous wealth $V'' = \dfrac{d^2V}{dy_t^2}$, $y_t = b(q_t)x_t - \theta\,x_t$.

Because $x_t = aS_t$ along a steady state path. This condition can be used to describe how environmental quality changes have impacts for activities that are perfect substitutes for accumulating experience in a recreational activity. Thus, both demands can be argued to convey information about the value of the environmental resource.

If there is a way to acquire the equivalent of aS_t through a program of instruction as a "take-it or leave-it" or extreme corner solution decision, then we should expect to find the demands for these programs to respond to changes in environmental quality--the same way as current demands of experienced users.

Thus, adding restrictions comparable to those used in other indirect approaches to non-market valuation expands the set of behaviors that should display a response to exogenous changes in environmental quality. The Becker-Murphy analysis focuses on how stock effects condition the behavior we should observe in the consumption decisions that create experience. The non-market valuation perspective on the role of experience suggests that if we focus on use values (i.e., impose weak complementarity between consumption and the resource), the dynamic consistency between consumption and experience stocks "creates" the equivalent of joint weak complementarities. As a result, it allows the analyst to use the decisions to acquire experience to infer the value for environmental quality changes.[31]

In practice, this relationship implies analysts should consider several decision margins in estimating people's values for environmental quality. Decisions to take skiing lessons, acquire scuba diving skills, or to participate in continuing education programs associated with

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[31] A potential application of the same logic to Becker's applications suggests that we should be able to jointly estimate the rates of participation in addiction treatment programs with the demand for the substances associated with the addiction.

specific uses of environmental resources convey information about the values these people have for the environmental resources that can be used once the skills are acquired. A Becker-Murphy rational addiction framework (together with weak complementarity) suggests environmental quality should have a comparable effect on the demands for the skilled recreation as it does for these educational programs.

V. RATES OF TIME PREFERENCE AND NON-MARKET VALUATION

There have been few little applied studies investigating the rates of time preference for amenities over time. As noted earlier, measures for the short term temporal substitutions estimated in Smith and Palmquist likely display a composite of the effects of time availability over the summer season and *ex ante* expectations about weather conditions. Unfortunately, the most ambitious study seeking to consider rates of substitution through time by Provencher and Bishop [1997] was forced to assume a very restrictive structure in order to implement an adaptation of Rust's [1988] dynamic discrete chronic models for the case of recreational fishing. Indeed the authors assumed recreationists considered only one site and did not discount future days of recreation in a single season in relation to current trips. They introduced a variable to reflect the elapsed time between trips, which seems to behave in a counterintuitive way in their estimated model. It has a negative and significant effect on the likelihood of taking a trip with all else held constant.

Several aspects of this important first step need to be highlighted as qualifications both to the interpretation of the effects of this elapsed time variable and to other dimensions of the authors' estimates. Both time and budget constraints are greatly simplified. The model assumes a daily budget constraint that is constant and unaffected by past consumption experience (except through satiation, e.g., meeting the total allocation of expenditures to fishing). This implicit separability of budgeting decisions, independent of performance or other features of the season, does not seem plausible. Likewise, while the constancy of the daily budget seems questionable, it is difficult to propose an alternative because we know so little about how people make these allocations. The treatment of time in the model has several additional arbitrary dimensions. The elapsed time variable has a fixed boundary and the season is limited at 133 days. Both considerations influence the way time contributes to the temporal substitution in their model. Nonetheless, their results do indicate that some inter-temporal substitution remains, due to time constraints which were significant influences to on-site time, as well as due to the expected weather conditions. We expect that the restrictions made to make the model computationally tractable partially explains their results which imply remarkably smooth patterns of values for daily trips over time.

Given these limitations, it seems reasonable to ask whether a less demanding approach, both from the perspective of data requirements and computational demands, can provide insights into how rates of time preference respond to improvements in environmental resources. Here is where a recent paper by Becker and Mulligan [1997] and their specified complementarity between goods linked to rates of time preference and future consumption appears to offer some new avenues for non-market valuation.

The Becker-Mulligan [1997] analysis of endogenous rates of time preference treats the discount factor as a function of a choice variable, G. They describe this variable as resources devoted to imagining future pleasures. While the model follows conventional practice by assuming time separable preferences, it does add two further restrictions. First, the time preference effect is multiplicatively separable from consumption of private goods, as in equation (4).

$$U = u_0(x_o) + \sum_{i=1}^{T} \beta(G)^i \cdot u_i(x_i) \tag{4}$$

where T is the individual's lifetime:

G = resource devoted to contemplating the future
x_i = private good
$\beta(\cdot)$ = discount function

Second, the resources devoted to contemplating the future, G, as it is given in equation (4), is assumed to be non-rival through time. The initial decisions about G determine the magnitude of the discount factor that applies to each period. Inter-temporal substitution between x_t and x_{t+I}, is at least partly, influenced by individual choices in allocating resources to "contemplating the future." Becker and Mulligan characterize this feature by suggesting that G and future utilities are complementary. Their discussion of the model's empirical implications focus exclusively on the "feedback effects" of changes in G that enhance the value of x_t in the future. That is, if we increase the prospect for future gains through increased longevity or better health, this creates an incentive to invest in future contemplation (i.e., increase G). Such reallocations of current resources reinforce the process by making those very gains more important through the reductions implied for effective discount rate (as a result of the increase in the current allocations to G).

In the absence of bequest motives, we can make a stronger statement than G is complementary to future utilities. The Becker - Mulligan model implies G is a weak complement to the set of future x_i's. If the x_i's are not demanded, then the value of G is zero. This seems trivial--one would not allocate resources to contemplate a future that provides no pleasures. However, it seems to hold promise for evaluating behavior if we also introduce environmental quality as a weak complement to x_i (i.e., u_i (x_i) in equation (4) is replaced by u_i (x_i, q_i)). The first point to notice in this modified formulation is that we expect future demands for x_i and for environmental quality to reveal the <u>same</u> information about the rate of time preference. The Becker-Mulligan specification implies x_i $(i > 0)$ and G will be weak complements. By confining the analysis to use values, the links provided by weak complementary between x_i and q_i $(i > 0)$ imply, with a model that has only one future period, we should observe the same information about the rates of time preference from either the demand for x_1 or the value of q_1.

To demonstrate this point consider how we might measure the economic value of allocating more resources (G) to contemplating the future. Assume that G is pre-determined in the initial period, then the value of a change in G from G_0 to G (G> G^0) using the measure of use of a resource x_1 (with $P_{x_1}^*$ the choke price and P_{x_1} another value for price permitting positive use) would be

$$\begin{aligned} WTP_{ss^0}^{x} &= \left[e(P_{x_1}^*, q_1, G, \overline{V}) - e(P_{x_1}, q_1, G, \overline{V})\right] \\ &\quad - \left[\mathrm{e}(P_{x_1}^*, q_1, G^0, \overline{V}) - e(P_{x_1}, q_1, G^0, \overline{V})\right] \end{aligned} \tag{5}$$

with e(·) the quasi expenditure function in current exogenous income. Weak complementarity implies that

$$e(P_{x_1}^*, q_1, G^0, \overline{V}) = e(P_{x_1}^*, q_1, G, \overline{V}) \,. \tag{6}$$

Alternatively, we could measure the effects of G using q

$$\begin{aligned} WTP_{ss^0}^{q} &= \left[e(P_{x_1}, q_1 = 0, G, \overline{V}) - e(P_{x_1}, q_1, G, \overline{V})\right] \\ &\quad - \left[\mathrm{e}(P_{x_1}, q_1 = 0, G^0, \overline{V}) - e(P_{x_1}, q_1, G^0, \overline{V})\right] \end{aligned} \tag{7}$$

The first and third terms are again equal because of weak complementarity. Thus using these simplifications we have:

$$WTP_{GG^0}^{x} = WTP_{GG^0}^{q} \tag{8}$$

The argument seems likely to have its most direct relevance to short-term rates of time preference where the values of future short-term events that preclude use might be compared to ones that have serious impacts on environmental quality. The Becker-Mulligan model (together with weak complementarity between x_i and q_i) implies individuals with comparable investments in patience should discount these events in the same way.

VI. IMPLICATIONS

People's uses of environmental resources necessarily involve time. Much of the literature reporting methods and estimates for people's values of maintaining or improving non-market resources has incorporated time as a measure of use or opportunity cost for choices involving those environmental resources. Time has a wider range of additional direct and indirect roles in people's decisions. Many analysts have argued that the only way economic models will be able to expand upon current understanding of true roles for time in people's choices would be to develop detailed time profiles from household diaries with specific records of time allocations that are maintained over a period long enough to address concerns about the "timing of time". Some recent experience with such diaries suggests they may be counterproductive, at least in the initial stage of research activities that must be associated with describing how time allocation decisions arise jointly with other consumer decisions involving environmental resources.

The reasons for this conclusion follow from what can be observed from the experiences of the studies conducted thus far. Data collection from people about how they spend their time and resources is a behavioral process. It is not a sampling of inanimate objects. The respondents are "giving" the researcher time and effort in the process of providing the information.[32] General requests for detailed diaries with complete records over extended time periods can lead to what is referred to as "conditioning" or "time-in-sample" biases.[33] Collecting records of usage without constraints on how the time can be used (e.g., facilities are open at defined times or the actions require specific conditions) together with the market and non-market constraints on an individual's time is unlikely to be informative. A record of activities over a predefined calendar does not resolve this. Provencher and Bishop's ambitious project illustrated the importance of this point. A key influence on their temporal description of willingness to pay was a set of choices (e.g., whether retired or not, and whether an entrant or not to a fishing tournament) that could have been accommodated in static models. Similarly, the information provided by the other dynamic efforts by McConnell et al. [1990] and Adamowicz [1994] rely on prior assumptions about depreciation of experience in the first case and a prescribed pattern of "price" (or travel cost) change over time for each respondent. There is no reliable empirical basis for either modeling decision. Collecting a panel will not help.

An alternative modeling strategy would suggest that the analysts must add more structure and a method for observing time relevant (and exogenous to the individual) constraints. This review has used Becker's models for time to propose two opportunities for using this logic. Becker's description of the rational addiction emphasized the complementarity between consumption over time is the key attribute. His focus was on developing a habit. In the context of environmental resources, the most direct application of this logic arises with the role of experience as a source for skill. Decisions to acquire training define one boundary that can be used to gauge the importance of the links in consumption of environmental resources over time. To the extent "purchased experience" or lessons substitutes for past consumption as a source of experience, the costs of these substitutes can reveal the importance of habits for current demand without a inter-temporal consumption record for each household.

The Becker-Mulligan description of endogenous rates of time preference also reduced the problem to a form of complementarity between forward looking goods and future streams of utility. In this case rational behavior suggests future gains from different sources

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32 See Smith and Mansfield [1997] for a discussion of these issues recruiting people to participate in surveys and their value of time.

33 An interesting critique and response to how these issues influence the development of a panel data set for a recreational fishing study is given in two detailed evaluations of how sampling affects the form and benefit estimates derived from travel cost recreation models (see Hanemann [1995] and Desvousges, Waters and Train [1996]).

(increased use versus improved quality during a specific future time of use) should be evaluated similarly. If not, the choices would not be optimal. This consistency across future sources of gain offers another type of boundary to be used in this case in estimating endogenous rates of time preference.

These two models illustrate how to frame the questions for analysis and, therefore, the types of information to collect. Without information on the evolution of constrains to individual decisions about allocating their time and money, a record of what people have done is incomplete. Most past studies have assumed nothing changed (Provencher and Bishop [1997]) or introduced somewhat arbitrary specifications (Adamowicz [1994]). A strategy that collects less data but imposes a clear focus on strategic choices seems more likely to be productive.

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