A Demand Theory for Number of Trips in a Random Utility Model of Recreation*

GEORGE R. PARSONS

University of Delaware, Newark, Delaware 19716

AND

MARY JO KEALY

U.S. Environmental Protection Agency, Washington, DC 20460

Received January 24, 1994; revised August 25, 1994

We present a simple random utility model of recreation site choice that incorporates an aggregate demand function for number of trips during a season. We derive the trip demand function using conventional demand theory and use it to calculate seasonal welfare changes due to improvements in site characteristics or addition of new sites. The model is based on Bockstael, et al.'s participation function. © 1995 Academic Press, Inc.

1. INTRODUCTION

A common data set for analyzing recreation demand includes information on the total number of recreation trips by individuals during a season and information on either the last site or all sites visited. The data usually exclude information on the dates and the order in which trips were taken, because gathering such information raises the cost of conducting a survey significantly.

Bockstael, Hanemann, and Kling [1] (hereafter BHK) were among the first researchers to analyze data of this variety. They developed a model that integrates site choice and number of trips using data on swimming trips to beaches in Boston. Their site choice model is a conventional random utility model in which individuals select a beach for swimming based on the characteristics and costs of reaching the beaches.

Their model for number of trips is a regression of the form

\[ T = g(s, I, u), \]

where \( T \) is the number of swimming trips taken during the season, \( s \) is a vector of individual characteristics, \( I \) is an inclusive value computed from the site choice random utility model, and \( u \) is an error term. The inclusive value is a preference-weighted measure of site characteristics and costs of reaching all sites—the more favorable the site the larger the \( I \). Equation (1) is like an aggregate demand

* We gratefully acknowledge Nancy Bockstael, Ted McConnell, and Ivar Strand for comments on a much earlier draft (Jan. 1990) of this paper and Michael Needleman, John Loomis, Frank Lupi, Edward Morey, Reed Johnson, three referees, and an associate editor for comments on more recent versions. The research was partially supported by a Cooperative Agreement with the U.S. Environmental Protection Agency. We express our views and not EPA policy.
function. Number of trips $T$ is the quantity demanded while price (cost of reaching the site) and commodity characteristics are imbedded in $I$.

BHK’s [1] modeling strategy is compelling. It is a logical way to incorporate trip demand into a site choice random utility model. Yet, there is little theory supporting Eq. (1). Our purpose is to show that with a slight modification of their approach, Eq. (1) may be interpreted as a demand function and used in a conventional way for welfare analysis.

We make no claim that the site choice and trip demand models presented here are derived from a single overall utility maximization problem. Rather, we claim to have developed an appealing and practical way to deal with trip demand in a site choice random utility model that improves on the strategy set out by BHK.

We begin with a brief presentation of the BHK approach and follow with our demand theory for number of trips.

2. THE CURRENT APPROACH

In BHK’s model people make decisions in two stages. A person first selects the number of trips to take during the season and second decides which site to visit on each trip. Consider site choice first.

2.1. Site Choice

Assume person $k$ takes $T_k$ trips and visits one of $N_k$ possible sites on each trip. The person has a site utility of $w(z_{ik}; \tau) + \varepsilon_{ik}$ for a trip to site $i$. The vector $z_{ik}$ is a set of characteristics of site $i$ including elements such as water quality and size of a body of water, and $\tau$ is a vector of parameters. We call $w(z_{ik}; \tau) - \alpha p_{ik} + \varepsilon_{ik}$ a person’s net site utility, where $p_{ik}$ is person $k$’s cost of visiting site $i$, which includes opportunity cost of time, travel costs, and other expenses associated with the visit. The parameter $\alpha$ is the marginal utility of a recreation dollar. The error $\varepsilon_{ik}$ is a set of unobserved characteristics known by the person but unknown by researchers.

Person $k$ chooses site $i$ if

$$w(z_{ik}; \tau) - \alpha p_{ik} + \varepsilon_{ik} > w(z_{jk}; \tau) - \alpha p_{jk} + \varepsilon_{jk} \quad \text{for all } j \neq i. \quad (2)$$

If the $\varepsilon_{ik}$ are independently and identically distributed (i.i.d.) type 1 extreme value random variables, McFadden [6] has shown that person $k$’s probability of visiting site $i$ on a given trip is

$$\pi_{ik} = \frac{\exp(w(z_{ik}; \tau) - \alpha p_{ik})}{\sum_{j=1}^{N_k} \exp(w(z_{jk}; \tau) - \alpha p_{jk})}. \quad (3)$$

Equations (2) and (3) represent the simple site choice model for each trip.

The parameters of the model ($\alpha$ and $\tau$) are estimated by maximum likelihood with data on trips taken by many persons. The likelihood functions is $\Psi(\alpha, \tau) = \prod_{k=1}^{K} \prod_{i=1}^{N_k} \pi_{ik}^{T_{ik}}$, where $T_{ik}$ is the number of trips taken by person $k$ to site $i$ during the season.
In the BHK model, site choice for any given trip is assumed to be independent of previous and later trips. Also, elements in the vector \( x_{jk} \) and the trip cost \( p_{jk} \) are assumed to be constant from one trip to the next. Recall from our opening paragraph that we assume time and order-specific information are unavailable. Hence, all diversity in site selection over the season is captured by variation in the error term \( \epsilon_{jk} \). The error term varies from one trip to the next and may change which site gives the largest utility on any given trip in Eq. (2). Relaxing this restriction will necessitate time or, at least, order-specific information.

From the perspective of the researcher, each of the \( N_k \) net site utilities, \( w(z_{jk}; \tau) = \alpha p_{jk} + \epsilon_{jk} \), for person \( k \) is a random variable. The expected value of the maximum of the \( N_k \) net site utilities is

\[
I_k = \ln \sum_{j=1}^{N_k} \exp\left(w(z_{jk}; \tau) - \alpha p_{jk}\right) + 0.577. \tag{4}
\]

This follows from the i.i.d. extreme value distribution assumption. \( I_k \) is the inclusive value discussed in our opening section.

Economic welfare on a given trip may change if the characteristics of sites are altered (say water quality is improved at one or more sites) or if the number of sites in a person’s opportunity set is altered (say a set of sites once closed to swimming are now opened). Money measures for these changes in economic welfare are calculated using \( I_k \). For an improvement in site characteristics at one or more sites the per-trip compensating variation for person \( k \) is

\[
cv_k = \left\{ I_k^1 - I_k^0 \right\}/\alpha. \tag{5}
\]

\( I_k^1 = \ln \sum_{j=1}^{N_k} \exp\left(w(z_{jk}^1; \tau) - \alpha p_{jk}\right) + 0.577 \), where \( z_{jk}^1 \) is a vector of characteristics at site \( j \) with the improvement, and \( I_k^0 = \ln \sum_{j=1}^{N_k} \exp\left(w(z_{jk}^0; \tau) - \alpha p_{jk}\right) + 0.577 \), where \( z_{jk}^0 \) is a vector of characteristics at the site \( j \) without the improvement. Equation (5) is just the difference in expected maximum utility with and without the improvement divided by the marginal utility of recreation income.

For increasing the number of sites in the opportunity set the per-trip compensating variation is the same as in Eq. (5). The only difference is how \( I_k^1 \) and \( I_k^0 \) are defined. If the number of sites is increased from \( N_k^0 \) to \( N_k^1 \), we have \( I_k^1 = \ln \sum_{j=1}^{N_k^1} \exp\left(w(z_{jk}^1; \tau) - \alpha p_{jk}\right) + 0.577 \) and \( I_k^0 = \ln \sum_{j=1}^{N_k^0} \exp\left(w(z_{jk}^0; \tau) - \alpha p_{jk}\right) + 0.577 \). The new sites are given the indices numbered from \( N_k^0 \) to \( N_k^1 \) and site characteristics are unchanged.

The \( cv_k \) in Eq. (5) is a per-trip compensating variation. If the number of trips taken by a person is the same with and without the improvement in site characteristics (or with and without the increase in number of sites) \( T_k \cdot cv_k \) is a plausible measure for the change in welfare for person \( k \) for the entire season. If, on the other hand, a person changes the number of trips taken in response to the improvement (or increase in number of sites), say the person takes more trips, \( T_k \cdot cv_k \) is inadequate. It misses the added consumer surplus for the new trips.

### 2.2. Participation

To account for the possible adjustment in number of trips, BHK introduced a participation function

\[
T_k = g(s_k, I_k, cv_k), \tag{6}
\]
where $T_k$ is the number of trips, $I_k$ is the inclusive value from Eq. (4), $s_k$ is a vector of individual characteristics believed to influence the number of trips taken and $v_k$ is an error term. Equation (6) and Eq. (1) are the same. Having $I_k$ in the participation function makes sense for reasons stated in our introduction. It is a preference-weighted average of the characteristics and prices of all sites in a person’s opportunity set. We expect a positive relationship between $T_k$ and $I_k$. For example, higher water quality leads to higher $I_k$, which in turn leads to higher $T_k$.

With the participation function the BHK model is estimated in two stages. First, the site choice model is estimated and the results are used to calculated $I_k$ for each individual. Second, the participation function is estimated. That function is used to predict how a change in site characteristics (or a change in number of sites) affects the number of trips taken by individuals. BHK estimate a Tobit version of Eq. (6) to account for nonparticipation. Creel and Loomis [3] estimate a Count model to account for nonparticipation and integer-only trip values.

Consider an improvement in site characteristics. Let $E(T^0_k)$ be person $k$’s predicted number of trips without an improvement, and let $E(T^1_k)$ be the predicted number of trips with an improvement. $E(T^0_k)$ is predicted using $I^0_k$ in Eq. (6), and $E(T^1_k)$ is predicted using $I^1_k$. $I^0_k = \ln \sum_{j=1}^{N_k} \exp(w(z^0_k; \tau) - \alpha p^0_k) + 0.577$, $I^1_k = \ln \sum_{j=1}^{N_k} \exp(w(z^1_k; \tau) - \alpha p^1_k) + 0.577$, and $E(T^1_k) \geq E(T^0_k)$. The seasonal welfare measure accounting for trip adjustment then is

$$CV^*_k = \frac{E(T^1_k)I_k - E(T^0_k)I^0_k}{\alpha}. \tag{7}$$

See, for example, Creel and Loomis [3, p. 2603]. The seasonal measure ignoring trip adjustment (see last paragraph of Section 2.1) is

$$CV_k = \frac{E(T^0_k) \cdot [I^1_k - I^0_k]}{\alpha}. \tag{8}$$

$CV^*_k$ is larger than $CV_k$ by the term

$$\left\{ \frac{[E(T^1_k) - E(T^0_k)] \cdot I^1_k}{\alpha}, \right. \tag{9}$$

the consumer surplus or value of net utility on new trips taken. The BHK model with the participation function allows us to pick up this added surplus, which may be significant for large resource changes.

What is missing in the BHK modeling strategy, however, is an explicit theory for Eq. (6). In the following sections we present an approach that incorporates a simple demand theory for Eq. (6).

### 3. A DEMAND THEORY FOR THE PARTICIPATION FUNCTION

We develop a site choice model and a trip demand model so that each is utility theoretic at its own level and in such a way that the behavior in the two models is consistent. The models are not, however derived from a single overall utility maximization problem in which site and trip demand decisions are made simultaneously.
3.1. Site Choice

Our site choice model is essentially the same as BHK’s. A person takes the total number of trips for the season as fixed and decides which site to visit on each trip. Unlike BHK, we assume that site utilities diminish as the number of trips taken increases. We make this assumption to provide consistency between our site choice and demand models. As we show in a moment it is of little consequence for estimating the site choice model.

On trip $t_k$ person $k$ has a recreation utility for site $i$ of $f(t_k) \{w(z_{ik}; \tau) + \epsilon_{ik}\}$. The terms $w(z_{ik}; \tau)$ and $\epsilon_{ik}$ are the same as before. The weight $f(t_k)$ captures diminishing site utility. As the number of trips taken increases, the utility at all sites diminishes according to $f(t_k)$. We assume $f(t_k) > 0$ and $\frac{\partial f(t_k)}{\partial t_k} < 0$. A lower case $t_k$ refers to a specific trip. An upper case $T_k$ refers to the total number of trips in a season. Trips are ordered as they would be along a downward-sloping demand function, in descending order of value (not chronologically), so the highest valued trip is first ($t_1 = 1$), second highest is second ($t_2 = 2$), and so forth. On the final trip in this order $t_k = T_k$.

A person’s marginal utility of a recreation dollar also diminishes as the number of trips increases. Since the utility of each dollar in the recreation budget is simply what it can purchase in terms of another recreation trip, its value declines at the same rate as the utility of trips. Hence, the utility of a recreation dollar on trip $t_k$ is $f(t_k)\alpha$, where $\alpha$ is a constant.

Person $k$ visits site $i$ on trip $t_k$ if

$$f(t_k)\{w(z_{ik}; \tau) - \alpha p_{ik} + \epsilon_{ik}\} > f(t_k)\{w(z_{jk}; \tau) - \alpha p_{jk} + \epsilon_{jk}\} \quad \text{for all } j \neq i. \tag{10}$$

The index $f(t_k)$ cancels out of this expression and hence has no influence on the choice of site on any given trip. It scales all site utilities and prices upward by a constant factor leaving the preference ordering of the sites unchanged. Since the net utility at all sites diminishes at the same rate, the ordering of the net site utilities is unchanged over trips. Since $f(t_k)$ cancels out of Eq. (10), our site choice model is the same as BHK’s. BHK’s site choice model then is consistent with a theory of diminishing marginal utility of trips over a season provided that the utilities at all sites diminish at the same rate.

BHK join their site choice and participation models by passing forward the inclusive value ($I_k$ in Eq. (4)) from the site choice to the participation model. Instead, we pass forward expressions for the expected price of a recreation trip and the expected utility of a recreation trip.

From our perspective as researchers the error terms $\epsilon_{ik}$ are unknown. Thus, from our perspective, person $k$ has an expected price of a recreation trip of

$$P(p_k, z_k) = \sum_{i=1}^{N_k} \pi_{ik} p_{ik}, \tag{11}$$

where $p_k = (p_{1k}, p_{2k}, \ldots, p_{N_k})$ and $z_k = (z_{1k}, z_{2k}, \ldots, z_{N_k})$. It is just a weighted average of the prices of all the sites in person $k$’s opportunity set. The weights $\pi_{ik}$ are the probabilities of visiting each site from the site choice stage (Eq. (3)). The higher a person’s probability of visiting a given site, the heavier the weight given to
the price for that site. \( P \) is a function of \( p_k \) and \( z_k \), because the probabilities \( \pi_{ik} \) are a function of both terms. \( P(p_k, z_k) \) is invariant over trips.

Similarly, from our perspective as researchers, person \( k \) has an expected utility of a site on trip \( t_k \) of

\[
W(p_k, z_k, t_k) = \sum_{i=1}^{N_k} \pi_{ik} \{ f(t_k) w(z_{ik} ; \tau) \}. \tag{12}
\]

Factoring out \( f(t_k) \),

\[
W(p_k, z_k, t_k) = f(t_k) V(p_k, z_k) = f(t_k) \sum_{i=1}^{N_k} \pi_{ik} \{ w(z_{ik} ; \tau) \}, \tag{13}
\]

where \( V(p_k, z_k) = \sum_{i=1}^{N_k} \pi_{ik} \{ w(z_{ik} ; \tau) \} \). \( W(p_k, z_k, t_k) \) is a weighted average of the individual site utilities. Again, a site that has a high probability of being visited weighs heavily in the index, a site with a low probability weighs lightly.

Expected price \( P(p_k, z_k) \) and expected utility \( W(p_k, z_k, t_k) \) are passed forward to an aggregate demand function for total number of trips taken during the season. We now turn to that model.

### 3.2. Trip Demand

We assume each person forms an "expected cost" and an "expected utility" of a recreation trip and bases the number of trips taken on these expectations. We assume that person \( k \)'s expected cost for a trip if \( P(p_k, z_k) \) from Eq. (11) and that his or her expected utility is \( f(t_k) V(p_k, z_k) \) from Eq. (13).

If \( f(t_k) V(p_k, z_k) \) is a person's expected site utility for a single trip \( t_k \), it follows that the expected utility for all \( T_k \) trips is just \( \sum_{t=1}^{T_k} f(t_k) V(p_k, z_k) \). It also follows that \( \sum_{t=1}^{T_k} f(t_k) V(p_k, z_k) = V(p_k, z_k) \sum_{t=1}^{T_k} f(t_k) = V(p_k, z_k) F(T_k) \), where \( F(T_k) = \sum_{t=1}^{T_k} f(t_k) \).

Assume for now that a person has a simple additive utility function in the trip demand model. He or she chooses \( T_k \) and \( x_k \), a nonrecreation composite good, in the following problem:

\[
\text{Maximize}\{ U(x_k) + F(T_k) V_k \mid x_k + T_k P_k = Y_k \text{ and } 0 \leq T_k \leq R \}. \tag{14}
\]

\( U \) is a utility function for nonrecreation goods \( x_k \). We assume that \( \partial U(x_k) / \partial x_k = u(x_k) > 0 \) and \( \partial u(x_k) / \partial x_k < 0 \). The price of \( x_k \) is 1. \( F(T_k) V_k \) is the utility function for recreation trips and \( V_k = V(p_k, z_k) \). Trip utility diminishes as the number of trips taken increases and does so at the same rate assumed in the site choice model. If we think of \( T_k \) as a continuous variable, we have \( \partial F(T_k) / \partial T_k = f(T_k) > 0 \) and \( \partial f(T_k) / \partial T_k < 0 \). \( P_k \) is a measure of the person's expected cost of reaching a site, \( P_k = P(p_k, z_k) \). \( Y_k \) is income for the season, and \( R \) is the number of recreation days in the season. Substituting the budget constraint into the utility function, we rewrite our problem as, choose \( T_k \) to

\[
\text{Maximize}\{ U(Y_k - T_k P_k) + F(T_k) V_k \}. \tag{15}
\]
The first-order condition for maximization, assuming no corner solution, is

\[
\frac{f(T_k) V_k}{u(Y_k - T_k P_k)} = P_k.
\]  

(16)

The individual takes recreation trips until the marginal expected value of a trip, \( f(T_k) W_k / u(Y_k - P_k T_k) \), is equal to the expected price of a trip, \( P_k \). The term \( f(T_k) W_k / u(Y_k - P_k T_k) \) is just the marginal utility of a trip divided by the marginal utility of a dollar.

Figure 1a is a graphic representation. \( MV(T_k) = f(T_k) V_k / u(Y_k - P_k T_k) \) is marginal valuation function for trips, \( P_k \) is the price index, and \( T_k^* \) is the number
of trips that maximizes utility. \( MV(T_k) \) is a declining function since \( \partial f(T_k) / \partial T_k < 0 \) and \( \partial u(Y_k - T_k P_k) / \partial T_k > 0 \). Notice that when a person selects \( T_k \) trips \( P_k T_k \) is implicitly allocated to a recreation budget and \( Y_k - T_k P_k \) is allocated to a non-recreation budget.

The decision to participate or not (take at least one trip during the season) is easy to analyze. If \( f(Y_k) > u(Y_k - 1P_k) \), the marginal value of one trip is less than the cost of one trip and a person does not participate. Reverse the sign and he or she participates. Figure 1b shows a nonparticipant.

The effect of improvements in site characteristics can also be analyzed. When characteristics improve, the expected utility of a recreation trip increases. The index \( V_k = V(p_k, z_k) = \sum_{i=1}^{N_k} \pi_{ik} w(z_{ik}; \tau) \) is a function of the characteristics at all of the sites in the person’s opportunity set. Improving site characteristics makes \( V \) larger through the changes in both \( \pi_{ik} \) and \( w(z_{ik}; \tau) \). Where \( V^{-1} \) is the index for the opportunity set with improvement and \( V^{0} \) the quality index without improvement, \( V^{-1} > V^{0} \). Larger \( V \) increases \( f(T_k) V_k / u(Y_k - P_k T_k) \) (shifts \( MV(T_k) \)) and increases the number of trips taken.

The expected price of a trip, \( P_k \), also changes with the improvement, but its direction of change is ambiguous. Recall that \( p_k = P(p_k, z_k) = \sum_{i=1}^{N_k} \pi_{ik} P_k, \) where \( p_{ik} \) is the cost of reaching site \( i \). Like \( V_k \), \( P_k \) is formed such that the costs of reaching the sites that are more likely to be visited weigh more heavily in the function. (If a person has a high probability of taking trips to nearby sites, the expected price will be low. If the person has a high probability of taking trips to far away sites, the expected price will be high.) Changes in site characteristics change \( \pi_{ik} \), which in turn change \( P_k \). Let \( P_k^{+} \) be the expected price with improvement and \( P_k^{-} \) be the expected price without. If the improvement occurs at sites with lower prices, then \( P_k^{+} < P_k^{-} \) is likely. If, on the other hand, the improvement is at sites with high prices then \( P_k^{+} > P_k^{-} \) is likely. A smaller \( P_k \) tends to increase the number of trips taken. A larger \( P_k \) tends to decrease trips. Improvements then have an ambiguous effect on the number of trips taken. Figure 1c shows a case where trips increase, and Fig. 1d shows a case where trips decrease. Figure 1e is an example of a person that takes no trips without the improvement but takes trips once an improvement occurs. Similar analysis can be done for increasing the number of sites in a person’s opportunity set.

It may seem unreasonable for the number of trips to decrease with an improvement in site characteristics. But, consider an improvement at sites far away from a person’s home. The person may increase the number trips to the far away sites but reduce the total number of trips over the season. Although each trip gives a higher utility, the higher cost of trips leads to a reduction in total number of trips. Some applications of the BHK approach have found negative signs on the inclusive value in the participation function. This behavior may explain such findings.

A trip demand function derived from our simple maximization problem will have the form

\[
T_k = g(P_k, V_k, Y_k, \kappa),
\]

which behaves like an ordinary demand function, with a price term \( P_k \), a composite utility or quality shifter \( V_k \), an income term \( Y_k \), an error term \( \kappa \), and parameters \( \kappa \). Demand shifters such as age, family size, and experience may be added in the
usual way. Equation (17) is our counterpart to the participation function (6).
Instead of entering the inclusive value $I_k$, we enter separate terms for expected
price and expected utility and then work with the equation as a demand function.

The model may be estimated in two steps. First, a simple discrete choice model
of site choice is estimated. Then, using the results from the site choice model price
$P_k$ and $V_k$ are measured for each person. Second, using these constructed values
for $P_k$ and $V_k$, the demand function, Eq. (17), is estimated.

Estimation of the trip demand function in Eq. (17) may be complicated by the
correlation of the error term, $\nu_k$, with $P_k$ and $V_k$. We might expect such correlation
for two reasons. First, $P_k$ and $V_k$ are generated regressors so we can expect
measurement error. Second, $P_k$ and $V_k$ are endogenous in the sense that they are
chosen by individuals in their choice of sites. The implication for estimation is to use
instrumental variables for $P_k$ and $V_k$. Candidate instruments include any measurable variable believed to be correlated with either index and uncorrelated
with the error term.

The model may also be estimated simultaneously (FIML) in a single likelihood
function. Let $Pr(T_k)$ be the probability that an individual makes $T_k$ trips. The full
information likelihood function is $\Psi^*(\alpha, \tau, \kappa) = \prod_{k=1}^{K} Pr(T_k) \prod_{t=1}^{T_k} \frac{1}{\pi_{i_k}} \Gamma_{t_i}.$

Welfare estimation is straightforward. For an improvement in water quality, the
seasonal consumer surplus is

$$CS_k^* = \int_{P_k^0}^{P_k^1} g(V_k^0, P_k, s_k) dP_k + \int_{V_k^0}^{V_k^1} g(V_k, P_k^1, s_k) dV_k.$$  \hspace{1cm} (18)

where $P_k^0$ is the expected price of a trip without improvement and $P_k^1$ is the
expected price with improvement. Similarly, we have $V_k^0$ without and $V_k^1$ with
improvement. The order of integration (over $P_k$ first or over $V_k$ first) is not
important. The $CS_k^*$ measure is path independent. The shaded area of Fig. If
shows $CS_k^*$ for the case where $P_k^0 > P_k^1$ and $V_k^0 < V_k^1$. For a change in the number
of sites in a person's opportunity set the consumer surplus looks the same. The
only difference is how $V_k$ and $P_k$ are calculated.

A perhaps troubling aspect of our model is the potential for a wrong sign on the
estimated welfare measures (18). Assume we have estimated a reasonable trip
demand model, so we have a positive sign on the expected utility term and a
negative sign on the expected price term. Say that sites located far away from
peoples' homes are improved, so the expected utility and expected price of a trip
rises. In theory, welfare must increase since the only change that has occurred in
individual's opportunities is an improvement in the quality of some sites. Yet, with
$V_k$ and $P_k$ rising, it is conceivable for the estimated changes in welfare to be
negative (see, for example, Fig. 1d). A similar argument may be constructed if $V_k$
and $P_k$ both fall.

This is not a serious drawback. Welfare measures are random variables. If the
true change in welfare is small, say positive but close to zero, it is conceivable that
the estimated values may, on some realizations, be negative. Presumably in
circumstances where the change is estimated to be near zero or even negative, we
would argue that the change in welfare is not statistically significantly different
from zero (in a one-tailed test). We would hope that a reasonably specified model
using data based on observed behavior would limit the occurrence of wrong signs.
4. A DUALITY-BASED APPROACH

The trip demand model may be analyzed more generally in an indirect utility function of the form \( \Omega(1, P_k, V_k, Y_k; \beta) \) where \( P_k \) and \( V_k \) are from the site choice model and are treated as price and quality parameters. The price of \( x \) is 1, and \( \beta \) is a vector of coefficients to be estimated. Derivation of Hickson's demands and measures of welfare follow convention.

The compensating variation measure for a change in quality at one or several sites or even a change in the number of sites included in the opportunity set is just the value of \( CV^\circ \) that solves

\[
\Omega(1, P_k^0, V_k^0, Y_k; \beta) = \Omega(1, P_k^1, V_k^1, Y_k - CV^\circ; \beta),
\]

where \( P_k^0 \) and \( V_k^0 \) are the values of price and quality in the without scenario and \( P_k^1 \) and \( V_k^1 \) are the values in the with scenario.

If separate models are estimated for day-trips and overnight trips the indirect utility function would take the form \( \Omega(1, P_k^{\text{day}}, V_k^{\text{day}}, P_k^{\text{night}}, V_k^{\text{night}}, Y_k; \beta) \). Hickson's demand functions would be derived separately for the day and overnight trips. This form has the desirable property of allowing for the substitution between trips of different length. One might consider a broader array of trip lengths such as day, weekend, and vacation (see Jones and Sung [5]), each having separate demand functions. One might even consider estimating demand functions separately for different types of recreation such as fishing, boating, and viewing.

5. CONCLUSION

Our demand theory offers a theoretical basis for analyzing number of trips taken in a random utility model for recreation. The demand model is based on Bockstael, Hanemann, and Kling's participation function and has several desirable properties. Most important are that the model (1) explicitly handles the decision of whether to participate in recreation or not, (2) allows for diminishing marginal utility of trips over the season, (3) accommodates substitution between number of trips taken and quality of site visited, (4) does welfare analysis at the seasonal level, (5) explicitly allows for adjustment in number of trips taken as quality or number of sites in a person's opportunity set changes in the welfare analysis, and (6) allows for substitution between day and overnight trips.

Our trip demand model is set in a different time frame than the site choice model. (See Morey, et al. [7] for an approach that sets both models in the same, per-choice occasion, time frame.) Our site choice model is per day (or trip) within the season. Our trip demand model is per season. Each is utility theoretic at its own level. The two models are consistent in the sense that both exhibit diminishing marginal trip utility over the season and that the price and quality (utility) indices used in the trip demand model are derived from behavior in the site choice model. For a first application of a model similar to ours see Feather and Tomasi [4].

REFERENCES


