THE HEDONIC TRAVEL COST METHOD

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Abstract—The hedonic travel cost method is a technique which reveals how much users are willing to pay for the individual characteristics of outdoor recreation sites. The prices of recreation attributes are estimated by regressing travel costs on the bundles of characteristics associated with each of several potential destination sites. The demand for site characteristics on site quality is then revealed by comparing the site selection of users facing different attribute prices. The technique is applied to value steelhead fish density in Washington State streams.

I. Introduction

CREDIBLE demand functions for goods provided by government are difficult to estimate because prices associated with marginal quantities purchased are conspicuously absent. Flood plain beneficiaries do not pay the providers of flood control for the different degrees of flood protection received nor do most recreationists pay public agencies for the qualities of recreation provided. Difficulties are further exacerbated when the goods and services are collective in nature and when there is significant quality variation in the level of services provided across locations. Bradford and Hildebrandt (1977) and Feenberg and Mills (1980) address this evaluation problem when the quantity of the public good varies across residential locations but each residence enjoys only one level of public good. In this paper, we focus on a different case, where residents actually face a menu of collective goods to choose from, each good offering different levels of characteristics.

By observing purchases of a private good (travel) which must be made to gain access to the public good (a recreation site), it is possible to observe a price for the public good (the site). Treating heterogeneous sites as if each was a bundle of characteristics, the site price can be decomposed into a set of implicit prices for each characteristic using the traditional hedonic method. If the relationship between the private expenditure and access to the public good varies across individuals, the individuals will face different implicit prices for characteristics. For example, each geographically dispersed resident in a region might face a different set of implicit prices to gain access to recreation site characteristics. Each residence zone would have its own price gradient. By observing the choices people make who face different opportunity costs to purchase the public good, it is possible to estimate the demand for the characteristics of the public good. The multiple market hedonic approach obviates the single market identification problem discussed by Brown and Rosen (1982).[1]

Because the hedonic travel cost is unique, it is helpful to contrast the method sharply from existing procedures. The hedonic travel cost method focuses on valuing the separate characteristics of a public good. In contrast, the Hotelling (1949)–Clawson (1959) travel cost procedure concentrates on valuing a specific bundle (site). Subsequent extensions of the single bundle approach to include substitute bundles (e.g., Burt and Brewer (1971) and Cichetti, Fisher and Smith (1976)) increase the generality of the travel cost method, but it is sites (specific bundles of characteristics) not the characteristics of those sites which are valued. For example, the travel cost method can measure the value of the Colorado River, the hedonic travel cost method can value scenic quality, fish density, crowdedness, etc.

Another relevant existing method is the household production function technique.[2] The household combines inputs such as household time, purchased goods (food, equipment, clothing), and a site to produce household commodities such as recreation activity days, harvest, photographs, etc. The household production function differs from the various travel cost methods in that it values the outputs of households rather than a site (an input). Given the household production function, it is possible to estimate the value of a site by determining the net contribution of the site to total output. However, if the sole purpose of the analysis is to value the site or the characteristics of the

Received for publication November 21, 1982. Revision accepted for publication November 15, 1983.
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This research was funded in part by the Division of Program Plans, U.S. Department of Interior. It is not responsible for the views expressed. We thank Mike Hay and V. Kerry Smith for their constructive advice.

[1] Brown and Rosen (1982) carefully describe the identification problem inherent in a linear model. For a more general discussion, see Mendelsohn (1983).

[2] See Bockstael and McConnell (1981), Brown et al. (1978), Charbonneau and Hay (1979), and Deyak and Smith (1978).

site, it is far easier to estimate the site's value directly. For example, to determine the value of a television, it is far easier to measure the demand for televisions directly rather than to estimate the demand for hours of television watched and from that estimate calculate the contribution of the television itself. This is especially true with the household production function because joint production, nonlinear output prices, and missing variables make the estimation of output demand difficult.[3] The hedonic travel cost approach avoids these econometric difficulties by valuing the inputs directly (the site characteristics) in terms of input prices (characteristic prices). Estimating observable input demand functions not only is easier, it is also more relevant for policy. The public agency or resource manager directly controls the characteristics of sites not the production of outputs by households. By knowing the value of game density, old trees, or improved campsites, the manager has all the information about benefits that he needs to allocate his scarce resources efficiently.

In section II, a theoretical model of outdoor recreation is presented. This model is then estimated in section IV from Washington State steelhead fishing data described in section III.

II. Theoretical Model

A representative individual's demand for outdoor recreation is the focal point of the following discussion. Outdoor recreation choices can be decomposed into two simultaneous decisions. (1) For trips of a particular length, how much average quality will the person choose? (2) How many trips will the person take of each length?

If all sites are alike, the rational individual will economize on time and other travel expenses by choosing the closest site. The fact that more distant sites are chosen implies that sites are not the same. A consumer's evaluation of the quality of sites is assumed to depend upon objectively measurable characteristics. Because it is plausible that individuals will value a characteristic more if they intend to enjoy that attribute longer, we distinguish between attributes for trips of different lengths. Each characteristic is consequently identified by type i (e.g., scenery, fish density, etc.) and length of trip l (e.g., one day, two days, five days, etc.).

The level of a given characteristic Z_{il} (averaged over trips of equal duration l), $i = 1, \ldots, I$, the number of trips N_l of each length l, $l = 1, \ldots, L$, and all other goods (X) enter the representative individual's quasi-concave utility function:

$$U(Z_{11}, \ldots, Z_{IL}, N, X)$$

where

$$N = \{N_l\}, \qquad l = 1, \ldots, L.$$

Although there may be no recreation user fees at sites, the total private cost of using different sites varies with its location. The further away a site, the greater the out-of-pocket costs of getting to the site. The slower the travel, the greater the time costs of the site per trip. The price of a trip providing a vector of characteristics, Z, is the sum of user fees, $f(Z)$, travel time costs, $C(Z)$, and travel costs, $T(Z)$, plus the fixed cost of the trips (a) such as the opportunity cost of time associated with the given duration of the trip. The fixed cost is assumed to be invariant to the site chosen.[4] The total cost or price per trip is

$$V_l(Z) = a_l + f(Z) + T(Z) + C(Z).$$

Travel time and expenses to a given site are independent of the length of trip so the subscript for trip length is not necessary for $f(Z), T(Z)$ and $C(Z)$.

Because the amount of time involved in traveling to outdoor recreation sites is non-negligible, the value of travel time can be a sizeable fraction of the cost of site access. Assuming that the value of time is equal to the marginal wage rate (ϕ) facing the individual, time costs will vary across individuals. Complicating this version of the model, it is likely that time spent traveling provides some enjoyment (utility). The typical user probably values his recreational travel time at only a fraction (α) of the marginal wage rate.

[3] Pollak and Wachter (1975), Barnett (1977), and Bockstael and McConnell (1981) all discuss the econometric difficulties introduced by the nonlinear budget constraints inherent in household production functions. On the one hand, there is an identification problem because marginal prices are not exogenous in this setting and on the other hand there is a selection bias problem. See Mendelsohn (1984) for a solution to the selective bias problem in this setting.

[4] Implicitly we assume that auxiliary goods, such as food and lodging, are invariant with respect to characteristics. If the cost of these facilities does consistently vary with characteristics, then the fixed cost of a trip of given length should also be a function of characteristic levels, $a(Z)$.

Urban commuter modal choice models (such as Domencich and McFadden (1975)) have found this to be true. Further, the cost per mile traveled for non-time expenses is also traditionally assumed to be a constant (β). Simplifying the model slightly, we examine the case where there are no user fees as this fits the empirical case discussed below. The total cost of a trip is consequently

$$V_l(Z) = a_l + \beta T(Z) + \alpha\phi C(Z)$$

where $T(Z)$ is miles traveled and $C(Z)$ is hours in transit.

The budget constraint facing the individual is

$$M = SX + \sum_l N_l V_l(Z) \tag{1}$$

where M is income and S is the price for non-recreational goods. In reality there may be other constraints such as limits on the number of vacation days available but data limitations force us to postulate a more abstract, partial model of recreation behavior. Utility maximization subject to the budget constraint yields the following first order conditions:

$$\begin{aligned}
&\frac{\partial U}{\partial Z_{il}} - \lambda N_l P_i = 0, \\
&\qquad\qquad (i = 1, \ldots, I),\ (l = 1, \ldots, L) \\
&\frac{\partial U}{\partial N_l} - \lambda V_l(Z) = 0, \\
&\frac{\partial U}{\partial X} - \lambda S = 0,
\end{aligned} \tag{2}$$

where $P_i(Z) \equiv \beta(\partial T/\partial Z_i) + \alpha\phi(\partial C/\partial Z_i)$ is the marginal hedonic price of characteristic Z_{il} per trip. The product, $N_l P_i(Z)$, is therefore the cost of a marginal improvement in Z_{il} aggregated over the number of trips taken (of length l).[5]

The price of a characteristic is the same whether it is enjoyed for one or more days because the relative prices of characteristics reflect only the cost of traveling to more distant sites. These travel costs typically do not depend on the duration of the trip. Whether an individual is willing to take the trip, and pay the price, however, may be a function of costs which vary with length of trip. Thus, although prices of characteristics are the same regardless of trip duration, the demand for characteristics associated with different length trips need not be identical.

The consumer's choice of outdoor recreation, expressed in terms of simultaneous demand equations, is obtained by combining equations (1) and (2) to give

$$Z_{il} = g(P, N, W) \qquad (i = 1, \ldots, N),\ (l = 1, \ldots, L) \tag{3a}$$

$$N_l = h(V_l(Z), N_k, W) \qquad (l = 1, \ldots, L),\ (k \neq l) \tag{3b}$$

where W is a vector of exogenous demand shift variables and $P = \{P_i\}$. N_k easily can be replaced by the price of the N_k^{th} trip, $V_k(Z), k \neq l$ and N by $a_1, \ldots, a_L$, which are the parametric components of trip prices not captured by P in (3a).

The supply of trips is assumed to be perfectly elastic to each origin. The cost of a second trip to any site is the same as the first trip. The supply of characteristics at each site is assumed to be fixed (unresponsive to prices) by exogenous factors.

To a first approximation, the consumer's surplus for a single price change is the integral of the product of average characteristics times number of trips,[6]

$$CS = \int_{P_i^0}^{P_i^1} \sum_l \{g(P, N, W) \times h(V_l(Z), N_k, W)\}\, dP_i. \tag{4}$$

Note that the marginal price affects both the average level of characteristic purchased and the number of desired trips (through $V(Z)$). The total consumer's surplus an individual is willing to pay

[5] In some cases it might be useful to write the utility function on a trip basis

$$N \cdot V(Z, X) \equiv U(Z, N, X).$$

In this case, the revised first order condition, $(\partial U/\partial Z_{il})/\lambda = \Pi_{il}$, has the transparent interpretation that the marginal value of a characteristic per trip equals its price.

[6] From the utility function

$$dU = \sum_i \sum_l ((\partial U/\partial Z_{il})\, dZ_{il} + (\partial U/\partial N_l)\, dN_l) + U_X\, dX = 0.$$

Substitute the necessary conditions from (2) into the expression for dU to obtain:

$$dU = \sum_i \sum_l (N_l P_{il}\, dZ_{il} + V_l(Z)\, dN_l + S\, dX) = 0. \tag{i}$$

Fully differentiating the budget constraint (1),

$$dM = \sum_l \left(dN_l V_l(z) + N_l \sum_i dV_l \right) + X\,dS + S\,dX, \tag{ii}$$

differentiating

$$V_l = \sum_i \int_0^{z_{il}} P(Y)\, dY,$$

is simply the sum of the consumer's surpluses the user will pay for each trip length. The total welfare associated with a change in average site quality chosen is the sum of the resulting changes in consumer's surplus added up across all individuals.

III. Data

To apply the hedonic travel cost method, we analyze a sample survey of about 5,500 randomly selected licensed fishermen in Washington. In this particular outdoor recreation survey, each participant identifies both his residence (origin) and favorite fishing sites (destination). The survey reveals the hours traveled and distance from the residential location to the fishing site, the number of trips taken to each site per year, and the average length of each trip.

Each fisherman also evaluates the characteristics of his favorite fishing sites: scenic value, crowdedness and the number of fish caught. The scenic and crowdedness measures run from 1 (the worst) to 10 (the best). The mean assessment of all the fishermen who use each site is defined as the characteristic of the site (river). For example, the average number of fish caught per day by all the respondents who visit a particular river is our measure of that river's fish density. Over 140 rivers are included in the study. The average value of scenery across sites is 4.5 with a standard deviation of 0.4, the average value for lack of congestion is 4.0 with a standard deviation of 0.5, and the average fish density is 5 (catch per ten days) with a standard deviation of 1.0. A unit of scenery or lack of congestion or two units of fish are about equal to the difference between an average site and an excellent site.

The mean assessment rather than the individual's judgment of a site's quality is used in order to focus on the objective characteristics of the site. Although it would be interesting to study how objective characteristics map into subjective evaluations which in turn lead to recreation choices, it is difficult to obtain consistent measures of subjective preferences. In the spirit of revealed preference analysis, only observable phenomena are studied. Also, because we use mean assessments, our measures of characteristics are continuous, not discrete.

IV. Analysis

The hedonic travel cost method is estimated in two stages. In the first stage, the implicit prices of characteristics are estimated for each of 63 residential locations. In the second stage, the number of trips and the level of characteristics are simultaneously estimated for each fisherman with two stage least squares. Independent regressions are performed for 1 day, 2–3 day, and 4 or more day trips. Although we display the simultaneous analysis, a simple least squares approach yields nearly identical results.

Two different sets of prices are estimated in the first stage: a time price and a distance price.[7] The distance prices are computed by regressing distance on the characteristics of fishing sites (scenery, crowdedness, and fish density). Travel time is regressed on the same characteristics in order to compute the time prices. The following regressions were estimated:

$$V(Z) = a_0 + a_1 Z_1 + a_2 Z_2 + a_3 Z_3$$
$$C(Z) = b_0 + b_1 Z_1 + b_2 Z_2 + b_3 Z_3$$

where $V(Z)$ is the miles traveled to each site and $C(Z)$ is the number of travel hours needed to get to each site. Each regression includes all the destinations of residents from a single residential zone. The independent analysis of each resident zone is necessary because people face identical prices only if they live nearby each other. Only the destinations people actually travel to are included because we are trying to identify the shape of the best possible frontier in characteristic space. Inclu-

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and substituting into (ii) yields

$$dM = \sum_l \left(dN_l V_l(Z) + N_l \sum_i Z_{il}\, dP_{il} + N_l \sum_i P_{il}\, dZ_{il} \right) + X\,dS + S\,dX. \quad \text{(iii)}$$

After making use of (i) and (ii) and assuming $dS = 0$, the income equivalent value of a price change in the i^{th} good consumer's surplus (CS) is

$$CS = \int_{P_i^0}^{P_i^1} \sum_l N_l Z_{il}\, dP_{il}. \quad \text{(iv)}$$

Substitution of equations (3a) and (3b) into (iv) yields equation (4) in the text.

[7] A separate time and distance price are estimated to permit the most flexible analysis of site opportunities. If speed to sites varies, the time and distance costs of purchasing characteristics could look quite different.

sion of sites which are clearly inferior (which have higher characteristic's prices) to the best set biases the estimation of marginal prices upwards.

The results of the 126 hedonic price equations are too numerous to display but can be summarized. For all origins, the most powerful explanatory variable is average density of fish at each fishing site. In the 63 regressions using distance as the dependent variable, 54 of the fish density coefficients are positive (implying positive prices) and 30 are significantly different from zero (with a 5% significance level). Scenery at the site is also important. In the distance regressions, 50 of the coefficients are positive and 14 are significantly different from zero. The importance of crowded conditions to fishermen is less apparent. The coefficient for fisherman congestion is positive less than two-thirds of the time. Congestion does not appear to be a consistent factor for steelhead fishermen when choosing sites. The regressions using time as the dependent variable are similar to the distance regressions except that the coefficients are more frequently indistinguishable from zero.

In order to compute the actual prices facing an individual, the hour and distance prices need to be combined in an appropriate index. To do this, we experimented with combinations of 30%, 60%, and 100% of wages for the value of travel time and \$.10 and \$.20 per mile for other travel costs in the demand regressions. In the absence of wage information, wages were proxied by income. The resulting price elasticities are robust across the various specifications. The intercept terms in the second stage, however, do change with the weighting of travel and time costs. The price coefficients are slightly more accurate statistically the greater the relative weight placed on mileage costs. The overall regressions fit slightly better the higher time is weighted by wages but this effect is due almost entirely to the growing importance of income (wages) as an independent variable in these regressions. Given the robustness of the results, we present only one set of findings where distance is valued at \$.10 per mile and time is valued at 30% of wages. The implicit price of characteristics becomes

$$\frac{\partial P}{\partial Z_i} \equiv .10\frac{\partial T}{\partial Z_i} + .30\phi\frac{\partial C}{\partial Z_i}.$$

Because the quality and number of trips of each length are chosen simultaneously, each of these variables are endogenous. We introduce an instrumental variable for number of trips by regressing trips on income, experience, and a dummy for each residential area. The predicted number of trips is then included as the independent variable in each of the reported characteristics demand regressions.

We first attempt to explain the number of trips people take of different length by regressing trips on income, experience, and prices. The trip regressions failed to provide a compelling explanation for the number of trips, the hypothesis of no linear relations is rejected at the 1% level. The results are disappointing but resemble the summary statistical properties of other similar studies using disaggregated cross-section data.[8]

The focus of our analysis, however, is upon estimating the demand for site characteristics. The average level of each characteristic—scenery, congestion, and fish density—is computed for annual 1 day, 2–3 day, and 4 + day trips made by each fisherman. In total, there are nine possible average values for each fisherman—the three characteristics times the three trip lengths. Because the prices of characteristics are estimated and not observed and because not all the price coefficients were significant, the price variables probably contain substantial measurement error. In order to prevent this measurement error from biasing the coefficients of demand price effects, we estimate the inverse demand function. The price of each coefficient is regressed on the observed level of characteristics purchased, income, experience, and the predicted number of trips of each duration. To acknowledge that the value of a characteristic for a trip may vary by length of trip, a demand equation is estimated for each characteristic for each trip length. All nine inverse demand equations are displayed in table 1.

For 1 day and 2–3 day trips, all six of the own price coefficients were negative as expected; four were significantly different from zero, and three of these were for the 1 day trip category, which constitutes 80% of the sample. The price elasticities evaluated at the mean for 2–3 day trips were much lower than the price elasticities for 1 day trips. For example, the fish density price elasticity dropped from −1.22 to −0.44 between 1 day and 2–3 day trips. The data for 4 + day trips suggest

[8] See, for example, Vaughan and Russell (1983).

TABLE 1.—THE INVERSE DEMAND FOR CHARACTERISTICS OF TRIPS[a]

	1-Day Trips			2-3-Day Trips			4+ Day Trips		
	Scenery	Lack of Congestion	Fish Density	Scenery	Lack of Congestion	Fish Density	Scenery	Lack of Congestion	Fish Density
Income	−0.0000 (0.70)	+0.0001 (4.35)	0.0026 (15.07)	−0.0000 (1.18)	+0.0000 (0.95)	0.0022 (8.87)	−0.0003 (2.49)	−0.0005 (2.30)	0.0068 (6.64)
Experience	+0.1704 (7.45)	+0.1190 (4.36)	−1.3997 (9.66)	+0.0696 (1.48)	+0.1371 (1.98)	−0.8359 (3.53)	+0.4701 (3.75)	+0.1568 (0.79)	−5.6922 (5.82)
Scenery	−3.0492 (6.26)	1.3702 (2.36)	−1.0110 (0.33)	−0.1765 (0.21)	0.2245 (0.17)	−8.9890 (2.07)	−1.8506 (0.61)	4.7799 (0.99)	+3.3353 (0.14)
Lack of Congestion	−1.4823 (4.06)	−4.6211 (10.61)	+7.2700 (3.14)	−2.2613 (2.64)	−1.2208 (0.97)	+0.8004 (0.19)	−0.2931 (0.13)	5.0967 (1.48)	−20.4927 (1.20)
Fish Density	−11.3478 (5.50)	−2.5396 (1.03)	−141.62 (10.83)	−8.7901 (2.48)	−10.5369 (2.02)	−47.5802 (2.66)	−4.1719 (0.36)	−29.79 (1.62)	116.4624 (1.27)
Predicted 1 Day Trips	−0.4000 (6.12)	+0.6362 (8.157)	5.3802 (12.99)	−0.3125 (2.98)	+0.1847 (0.72)	4.4155 (8.33)	−0.9422 (4.00)	−0.56105 (1.51)	16.1085 (8.76)
Predicted 2–3 Day Trips	−2.8729 (8.17)	−0.2510 (0.59)	20.5817 (9.23)	−1.2163 (1.99)	−3.0383 (3.38)	6.8142 (2.22)	−5.1997 (3.25)	−2.6522 (1.05)	63.8145 (5.11)
Predicted 4+ Day Trips	−4.7521 (6.56)	−14.3178 (16.56)	5.6275 (1.23)	−2.8781 (2.04)	−6.3424 (3.04)	−11.3767 (1.59)	−18.0789 (6.25)	−9.8586 (2.16)	97.1683 (4.29)
Constant	−4.5052 (1.22)	21.5279 (4.89)	−55.7792 (2.39)	−9.8579 (1.49)	−7.0641 (0.72)	−86.1250 (2.57)	−36.4466 (1.70)	−85.7263 (2.55)	−615.1662 (3.68)
Adj. R^2	.124	.215	.20	.057	.118	.279	.474	.124	.646
F	35.46	67.65	62.46	4.61	8.90	23.73	8.32	2.15	15.83
# Observations		1950			471			66	

[a] The dependent variable is the price of each characteristic. t-statistics are in parentheses.

that the demand for characteristics for long trips is even more price inelastic but this last sample is too small to make strong inferences.

The price effect of other characteristics is negative in 12 out of 18 cases which suggests that the characteristics are substitutes for each other because of the inverse form estimated. Both lack of congestion and fish density respond positively to higher incomes (except for congestion and the long trips) which suggest they are normal goods. Scenery appears to be an inferior good when combined with long trips. Fishermen are willing to pay more for scenery and lack of congestion if they are more experienced. Experienced fishermen, however, are not willing to pay as much as the inexperienced for fish density. It could be that as one's skills increase, the added challenge of catching fish in a low fish density stream becomes relatively more attractive. With scenery and lack of congestion, the more trips one expects to take, the less one is willing to pay for each characteristic per trip. The reverse is true for fish density. The more trips fishermen took, the more they were willing to pay for fish density per trip.

V. Conclusion

The hedonic travel cost method attempts to extract the value recreationists place on public lands through their revealed preferences. By observing how much further fishermen travel to reach better quality sites, it is possible to estimate a price for quality. This price is specific to each residential location—people who live closer to the better fishing sites face lower prices. By comparing the fishing behavior of people who face low versus high prices, it is possible to estimate a demand curve for the average quality per trip.

In the analysis of Washington steelhead fishermen, three characteristics of public lands were tested: congestion, scenery, and fish density. Fishermen travel further distances to obtain higher qualities of all three characteristics. The most valuable characteristic, however, appears to be fish density.

Assuming that the value of travel time is 30% of wages and travel costs about \$.10 per mile, catch per ten days has an average price of \$4.80 per trip or \$110 per season.[9]

Another finding is that the demand functions for all characteristics are price sensitive. Average prices consequently yield poor measures of the value of significant changes in site attributes. The price underestimates (overestimates) the value of a sizeable decrease (increase) in characteristic levels. For example, a 20% decrease in average fish density (from 0.4 to 0.32) is worth about \$88 per season to the average fisherman evaluated at a constant price. Using equation (4) and computing the consumer's surplus, the true loss of a 20% fall in fish density is \$99 per season to the average fisherman. The use of hedonic prices rather than implicit demand functions to value nonmarginal changes in characteristics can result in sizeable valuation errors.

[9] Catch per ten days is used as a measure of fish population. The seasonal marginal willingness-to-pay is computed by multiplying the per trip marginal willingness-to-pay of \$4.80 by the average number of trips (23).

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