An Application of the Hedonic Travel Cost Method to Valuing Recreational Fishing

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I. Introduction

How can the recreation value of a site be estimated when there are no prices charged for the recreation services provided? Harold Hotelling answered that question for the National Park Service many years ago. He set forth what is now called the travel cost technique. The driving force behind this technique is that people from different origins bear different travel costs to reach a common site. Therefore, they can be expected to participate at different rates. Two features of this technique bear mentioning. First, the technique captures an all-or-none value for the site. It does not provide information about the marginal value of changing the site a little bit, say, by improving its quality in some fashion. Second, in practice, the procedure assumes that all face the same opportunities to enjoy substitute locations at the same price; that is, substitutes are omitted from the analysis. The consequence of omitting substitutes when they do, in fact, exist, is to overestimate the value of improvements at a site and to underestimate the loss due to quality changes at a site.

Fortunately, including substitutes in the analysis solves the second problem and also responds to the first problem. Burt and Brewer (1971) were the first to generalize the travel cost technique to many sites and their study is the point of departure for the analysis below. In contrast to Burt and Brewer, in the analysis below, we feature the quality and the

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location of the sites, measured by expected success at sites, whereas their sites were assumed to differ only in location.

II. The Hedonic Travel Cost Method

We assume that each recreation site has a bundle of characteristics. Consumers at a given origin, by incurring the costs of traveling a bit further, can obtain a richer bundle of characteristics. Thus in the first step of the analysis, the marginal cost (implicit price) to the "consumer" of obtaining one more unit of a characteristic is estimated. Notice that this step is the opposite of the application of the usual travel cost technique. It features one site, to which come visitors from many origins. We pick one origin and estimate the cost of reaching different sites. The derivative of the cost function with respect to each site characteristic from this first stage regressions yield the implicit price of each characteristic for that markert (origin).

Since people from different origins (markets) face different opportunities, each time this first step is repeated for a different origin provides a new set of implicit prices for the characteristics.

In the second stage, the quantity of characteristics each recreationist enjoys is regressed on the prices of the characteristics and other demand determinants such as income and age. This step yields a demand curve for each characteristic from which the marginal value of a characteristic can be computed.

Put more formally, we assume that the consumer's evaluation of the quality of sites depends upon objectively measurable characteristics. That is, the characteristics (Z_i) of sites, the number of trips taken (L), and all other goods (X) enter the representative individual's quasiconcave utility function:

$$U(Z_1, \ldots, Z_n, L, X).$$

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. The price of the j^{th} site providing a vector of characteristics, Z, is the sum of entry fees f (Z), and travel costs, T(Z), plus the fixed cost of the trip, 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. The total cost or price per trip is

(a) $$V(Z) = a + f(Z) + T(Z).$$

The budget constraint facing the individual is therefore:

(2) $$M = SX + LC(Z),$$

where M is income and S is the price vector for non-recreational goods. Utility maximization subject to the budget constraint yields the following first-order conditions:

(3) $$U_{Z_i} - \lambda L(f_{Z_i} + T_{Z_i}) = 0, \qquad (i = 1, \ldots, n)$$

$$U_L - \lambda V(Z) = 0,$$

$$U_X - \lambda S = 0,$$

where λ is the Lagrangian associated with (2) and is interpreted as the marginal utility of income.

The sum, $f_{Z_i} + T_{Z_i}$, is the marginal price of characteristic Z_i per trip.

The consumer's choice of outdoor recreation, expressed in terms of two simultaneous demand equations, is obtained by combining equations in (2) and (3) to give

(4) $$Z_i = g(f_{Z_i} + T_{Z_i}, L, W), \qquad (i = 1, \ldots, n)$$

(5) $L = h(V(Z), Z, W)$,

where W is a vector of exogenous demand shift variables. V(Z), the cost of a trip, in equation (5), can be expressed in terms of its component parts. Thus equation (5) could also be expressed:

(5a) $L = h(f_Z + T_Z, a, Z, W)$

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.

In the empirical study below we have explicit information on only one relevant site characteristic, success. The intercept term of the first-stage regression picks up the mean effect of the left out characteristics. It can be used as a proxy for the price of other characteristics. Since we have no measure of quantity for the left out characteristic, it's demand equation cannot be estimated. Thus we estimate two demand equations, one for trips and the other for success.

III. Data and Variables

The questionnaire from which the basic data were drawn has been carefully described elsewhere in the overall report to which this study is a contribution. Briefly, a sample of 9,000 was drawn from those purchasing angling licenses in Oregon in 1977. The sample was about 1.5 percent of the total angler licenses. About 1,200 were mailed questionnaires in the first and last quarters of the calendar year, about twice that number and three times that number received questionnaires in the second and third quarters, respectively. Just under one-half the questionnaires were at all usable, a much smaller number (405) were primarily interested in salmon and a smaller fraction responded to questions critical for our analysis.

The sample was further reduced to 290 because of the necessity of having a minimum number of responses from a given origin, necessary to run a first-stage regression, from which the implicit prices are obtained. We arbitrarily set the minimum acceptable number of observations from a given county to 5 which limited the study to 14 counties; i.e., 14 prices.

Distance (AVDN) – The reported round trip distances from any given county to any given salmon fishing location by (county or site) was averaged across respondents, to provide an estimate of distance.

Success (DST) – Respondents reported success and effort in the questionnaire. From these responses, each site's catch per unit of effort was estimated. We take this as the measure of site quality. Suppose everyone was equally competent at catching salmon. It is the nature of fishing that, during a given period, success will vary across people of equal capability. People fish where they fish, based in part, on expectations which we take to be the sample mean of success per hour fished. Thus the actual success of a fisherman is regarded as the true value plus random variation. Ideally, a site input characteristic such as fish density would have been a more objective variable to use but this was inaccessible to us.

Success per hour (ASE) – This is average catch per hour (DST) aggregated across the sum of the trips taken by an individual to different sites. There is an ASE for each individual in the sample.

Initially, we computed an area's success for other species of fish because we thought they might be valuable characteristics. The other species either were insignificant or, in the case of steelhead, very highly correlated, so they were dropped from the analysis.

Trips (N) – Individuals provided the number of trips they went salmon fishing during the quarter in which they were sample. It would have been desirable to have an estimate of the number of salmon trips per year, under the reasonable assumption that trips during April, May and June are a substitute for trips during July, August and September. 80 percent of the trips were taken during the period sampled in the present analysis.

Income (INC) – The questionnaire asked respondents to check the income range of the gross income for all members of their family. The mid-point of each range was chosen.

Mileage Costs – The first stage regression produces prices measured in miles (actually, marginal miles). Under some conditions, the second stage demand function could be estimated in terms of miles and finally expressed in the more conventional dollar value terms. Earlier analysis of the data at OSU explicitly recognized that some recreationists travel in vehicles with low gas mileage and others in vehicles with high gas mileage. Thus the price of miles differs across individuals. We use the mile cost estimates of the earlier study,

Autos and Pickups,	9.75 ¢/mile
Motor Homes and Campers,	11.60 ¢/mile,

obtained originally from the Department of Transportation.

Time Cost–While everyone can agree that the opportunity cost of travel time is a relevant concept, there is no consensus and theoretically defensible empirical estimate of the opportunity cost of time during a trip to a recreation site. The controversy over the issue is easily accessible elsewhere and won't be discussed here. A basic estimate of time cost is found by estimating a wage rate on the strong assumption that all reported income is earned and further that each respondent works 2,000 hours per year. The wage rate ($/hor) can be transformed into a mileage cost ($/mile), given the rate of travel (miles/hour)– 40 or 35 miles per hour if travel is by auto or camper respectively – and an assumption about the fraction opportunity cost of time is to the wage rate. This fraction is assumed to be 30 percent of the gross wage which is on the order of 50 percent of the wage rate net of taxes.

Entry Fee (f) – It is reasonable to assume that higher access costs are associated with higher quality sites, particularly since charter boats at the ocean generally provide better fishing quality. The reported costs of guide service, rental of equipment, boat launching fees and gas for boats are taken to represent the entry fee or fixed cost for a site.

Age was tried as an explanatory variable in the demand equations but never was significant so was dropped.

IV. Estimation

The first stage regression, equation (1) was run in linear form for each of the 14 counties which had 5 or more fishermen in the sample. An illustrative regression for Washington County salmon fishermen is

$$\text{(6)} \quad \text{Distance} = \underset{(3.10)}{50} + \underset{(5.49)}{247} \ \text{Success Per Trip}$$

$$\bar{R}^2 = .74$$

The interpretation of equation (6) is that for a twenty percent increase in success per trip from .30 to .36, a salmon fisherman would have to drive 15 more miles

$$(\Delta \text{ Distance} = 247 \text{x} \Delta \text{ catch per trip}).$$

In general, 9 of the slope or implicit price coefficients were positive as they should be and 6 had t-values greater than 1.85. 5 had negative slope coefficients. Only one was statistically significant. The intercept coefficients were all positive and 6 were statistically significant (t-values greater than 1.85). These results are not particularly good and the reason is straightforward. The study was designed to collect data for a different purpose other than for application of the hedonic travel cost technique.

Appropriate data for this type of study are economically acquired by cluster sampling around origins. In the first-stage we are seeking a cost function representative for a given group of people. The group is one which faces common-market prices; i.e., whose distance to an expected quality is the same. We do not need a sample representative of the state at this point, as the original study quite rightly was designed to do.

We experimented with non-linear representations using squared terms for the independent variable but these did not fit any better although there were a couple of exceptions.

The coefficient for catch per trip obtained from the first-stage regression provides the implicit prices of catch per trip for each of the 14 counties in the regression. The value of 0 was substituted for negative implicit prices on the assumption that 0 is a better estimate of the marginal value of success than a negative value. The constant term in each of the regressions represents the mean value of the left out characteristics, measured in miles.

In the second stage regression, the catch per trip at the site where each individual fished is regressed on the price of that catch level obtained from the county regression in which the individual lives. The sample size is the number of people in the sample, 290. Other independent variables are number of trips and income. Figure 1 illustrates this regression. Scattered along a horizontal price line (price = 247) are all the salmon fishermen in some county (say Washington) who are in the sample. They went different places and each place had a different catch per trip.

Equation (7) represents the simplest second stage regression estimating the demand function for success.

$$\text{(7)} \quad \text{Catch per hr} = \underset{(3.5)}{.14} - \underset{(-2.54)}{.2\text{x}10^{-4}} \text{ (PSAL} - \underset{(-1.65)}{.14\text{x}10^{-2}}$$

$$\text{Trips} + \underset{(.88)}{.34\text{x}10^{-6}} \text{ INC} \qquad \bar{R}^2 = .02$$

where PSAL refers to price in miles.

Catch per hour is an unusual dimension to use. We can convert to the more usual concept of catch per trip using an hour per trip estimate. Our analysis obtained an average of 3.45 hours per trip but this was only the actual fishing time. Sorhus (1980) found a sample average of 6.8 hours per trip, conventionally defined. For purposes of comparison with other estimation techniques, we convert our estimates to conventional concepts using the fraction of Sorhus' estimate to ours (6.8/3.45 ≐ 2.0).
3.45

The elasticity of demand using (7) evaluated at mean catch per trip of .39 using Sorhus' estimate of hours per trip is .18, twice the estimate obtained using unadjusted hours per trip. This seems like a very inelastic demand function. If it is true, or nearly so, it means that studies which compute a constant value of success, as compared to computing a function will be greatly in error except at the mean. Practically, this means that such studies will badly underestimate the economic losses resulting from actions which reduce success and badly overestimate benefits from success improving activities. The cross-hatched area in Figure 2a and 2b illustrate the error in assuming that the value of catch per trip is constant independent of the level of success.

Taking the inverse of (7), converting to catch per trip and suppressing the other independent variables yields

$$\text{(8)} \quad \text{PSAL} = \text{constant} - 7{,}245 \text{ catch/trip}$$

using the Sorhus estimate of 6.8 hours per trip (the slope coefficient is 14,490 if hours per trip is 3.45). Equation (8) is illustrated in Figure 1.

The sample mean catch per trip is .39. We are unable to explain this very low rate of success. From the Oregon Department of Fish and Wildlife data we estimate ocean catch per trip = 1.03 and fresh-water catch per trip = .30. Our sample contains 58 percent ocean trips and 42 percent river trips. Applying these weights to respective success estimates yields a catch per trip of .70 which is 1.8 times greater. As a practical matter, this unresolved discrepancy creates a great range in our value estimates.

The sample mean unit is 502 miles. As in the usual demand equation, this means that, on average, Oregon salmon fishermen in this sample went ("paid") 351 miles per trip to catch salmon ($\frac{502}{\text{Fish}}$ x .70 $\frac{\text{Fish}}{\text{Trip}}$)— — using state mean catch data—see Figure 1.

Consumer's surplus (CS) evaluated at the mean catch per trip is

$$\text{(9)} \qquad CS = \int_0^{\bar{Q}} f(\bar{Q})\, dQ - \bar{Q}f(\bar{Q}) = \frac{-a_1\bar{Q}^2}{2}$$

where a_1 = 7,245.

$\bar{Q}$ = sample mean catch per trip = .39 or .70.

f ($\bar{Q}$) = the inverse demand function in (8).

Thus consumer's surplus is 550 or 1,773 miles per trip or \$55 or \$177 per trip evaluated at \$.10 per mile. This seems a bit high unless, possibly \$.10 per mile includes some measure of opportunity cost of time. Although \$.10 per mile is a reasonable estimate of out-of-pocket expenses, perhaps they should be adjusted by the number of fishermen in the car. Is it reasonable to assume that expenses are shared in fact or in effect, by each party taking turns in the vehicle taken?

With the equation above, the average value per fish can be computed for any level of catch. Evaluated at the mean the average value of a salmon is CS/Q or $CS/Q = -\alpha_1 Q/2$.

The average value per fish is about \$141 or \$254 evaluated at \$.10 per mile and .39 or .7 catch per trip respectively. This seems to be a high range.

The marginal consumer's surplus (MCS) addresses the amount a salmon fisherman would pay to have success at a fishing site improved. For example, what is they value per trip on average of increasing success per trip 10 percent? From (9)

$$(10) \quad MCS = \Delta CS = -\bar{Q}f'(\bar{Q})\,\Delta Q.$$

At the average of .39 or .70 fish per trip, salmon fishermen would pay 113 or 355 round trip miles, \$11.30 or \$35.50 at \$.10 per mile for an improvement of an average of 10 percent fish per trip.

Having estimated the demand for catch per trip, one can compute marginal consumer's surplus at any level of success using (10) and (8). Thus the value of improving a site yielding 25 percent below average success can be compared with the cost of the improvement. Or the value of improving a site yielding a high catch per trip can be compared with the cost of improvement.

The demand equation just discussed has the simplest estimate of price. Price is measured in marginal miles. The advantage of such a formulation is that the reader is free to select any unit mileage cost. For example, if it is believed that the opportunity cost of time is 30 percent of the wage rate after taxes and the average speed of traveling is 40 mph, then this is equivalent to adding about \$.06 per mile to the out-of-pocket mileage costs.

A word of caution needs to be expressed about the dependent variable in the demand equation, catch per trip. Many of the fishermen sampled fished at more than one site. Catch per trip for each individual is computed as the average of catch per trip for each of the sites visited. Strictly speaking, it is the level of success of nowhere in particular. That is just an abstract characteristic of all averages.

Of more interest is that the averaging computation is necessary in order to circumvent pseudo irrational behavior. When fishermen face a fixed and constant unit price for success, each should choose the one site and number of trips to that site which maximizes utility. With x characteristics, there is at most x activities (sites) which a fisherman should visit. Models which capture only the value of one characteristic such as success, using data from individuals observed to visit more than one site, are logically inconsistent.

Of course we know what the problem is. Fishermen may choose different sites because they have different amounts of time available or because one trip is a family outing and another is with fishing cronies. However, if we don't structure a questionnaire to obtain these distinctions, there is a real possibility of making inappropriate policy decisions. The estimates might show that it is beneficial to increase the density of salmon at one fish per day sites–where the one fish node is an average of better and worse sites actually visited. In fact, densities should have been augmented at the sites hidden by the averaging process, not at the one fish per day site.

The danger discussed above arises when the technique is used for valuing characteristics of a location. The problem is inconsequential when only average values are desired. In this case, there is no particular reason to use a hedonic technique which is expensive because it uncovers a marginal function when a cheaper technique uncovers a constant, the average.

Table 1 summarizes other regressions involving more complicated estimates of implicit price and a double log specification.

The independent variable PSA, is the dollar measure of miles and further includes the marginal opportunity cost of time reckoned at 30 percent of the hourly wage rate. The independent variable, PSAF, is the sum of PSA and the marginal fixed cost of a trip which varies with catch per trip. The fixed cost includes expenditures on guide service, bait, rental equipment, boat launching and gas for a boat. It excludes camping and lodging fees and food and drink expenses on the assumption that these do not vary with catch per trip. Although value is obtained from these latter expenditures, there is little reason to believe that the marginal utility of food varies with marginal catch.

In linear form, the slope coefficients in regressions with the implicit price using distance in money terms (PSA) or the price including the fixed cost which varies with success (PSAF), are the same. The logarithmic form of the regression using SAL produces a low estimate of the elasticity of demand (.08). Apart from a higher elasticity of demand (.14 vs. .08) the log-log demand function with fixed costs in (PSAF) closely resembles the demand function omitting final costs. In none of the regressions is income or number of trips statistically significant. While cross-section analysis usually does not produce a very high R^2, the R^2 in all of the regressions is very small.

The number of trips (L) a salmon fisherman takes is assumed to be a choice variable so there is a corresponding demand function for trips. The following semi-log specification had the most desirable statistical properties.

$$(11) \quad \ln L = \underset{(8.67)}{1.12} - \underset{(-2.39)}{.63\text{x}10^{-3}}\, PSA - \underset{(-2.57)}{1.71}\text{Catch Per Trip} + \underset{(.76)}{.35\text{x}10^{-5}}\, INC \qquad R^2 = .03$$

where PSA is the marginal price of success each person faces, and INC is income. Income is not significant but the other variables are. It seems reasonable that trips should vary inversely with the price of a success but it is less obvious why trips fall as the quality of a trip (catch per hour) rises. A quality increase, increases the total cost of a trip even when the price per unit of quality is constant. In this model, total cost is the product of price per characteristic and characteristic level (plus a constant). Trips should fall when the total cost of a trip rises.

V. Conclusions

The application of a hedonic technique to the Oregon State sport salmon fishing data was an experiment with limited success. For the technique to be empirically successful, the number of origins of fishermen selected must be large enough to produce an adequate sample size in the second stage regression. The nature of the data collected limited us to only 14 sample origins. The original sample was designed with other legitimate purposes in mind.

The number of people in each origin must be large enough and go to sufficiently different places with sufficient variations in the level of the characteristics to permit a reasonable chance of obtaining a decent set of regression coefficients for each origin selected. There were neither large enough numbers of people nor varied enough locations to give us a great deal of confidence about the estimates. Care in sample design will have to be executed in future applications of hedonic travel cost techniques.

TABLE 1

DEMAND FOR SUCCESS UNDER ALTERNATIVE SPECIFICATIONS

	Catch Per Hr.							
	Linear		Logs					
	β	t-value	β	t-value	β	t-value	β	t-value
SAL			–.087	–3.69				
PSA	$-.48 \times 10^{-4}$				–.08	–3.58		
PSAF							–.14	–2.77
N	$-.14 \times 10^{-2}$	–1.64	–.106	–1.36	–.11	–1.35	–.11	–1.42
INC	$.61 \times 10^{-6}$	1.52	.063	.57	.11	1.00	.10	.84
Const.	.13	13.89	–2.54	–2.39	–3.12	–2.90	–2.60	–2.41
$\overline{R}^2$	.17		.04		.04		.03	

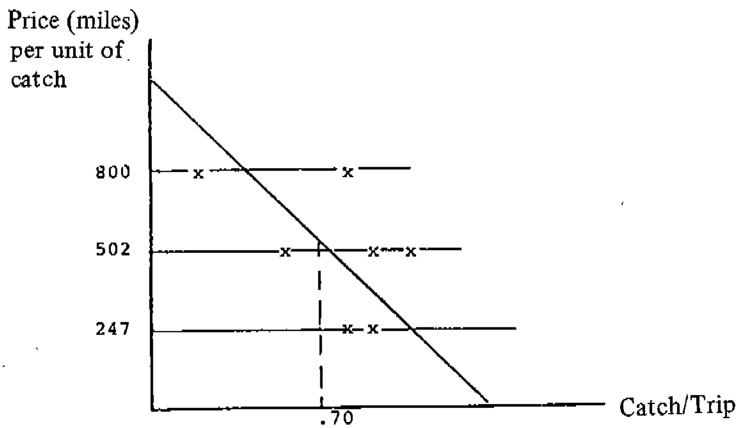

Figure 1. Demand for Success

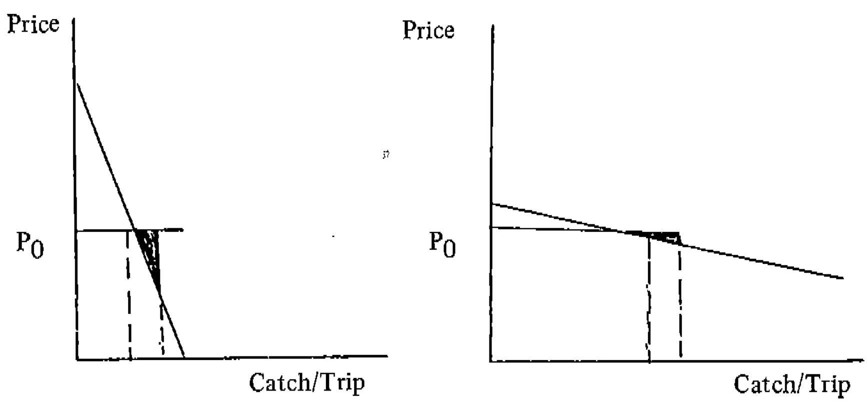

Figure 2a. Inelastic Demand   Figure 2b. Elastic Demand

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應用特徵旅遊成本法估計遊憩性釣魚之效益

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摘 要

由於傳統的旅遊成本法只着重於遊憩場所本身所產生的經濟效益，而無法針對遊憩場所內的每一特徵項目估計出在管理上非常有用的隱含價格，所以在實際應用上仍有其限制。爲解決上述問題，近幾年陸續有人建議採用特徵旅遊成本法；本文即試圖將此一方法應用於美國奧勒岡州鮭魚的遊憩效益之估計。結果顯示這一方法的應用並不如預期中的理想，主要原因是這些資料的取得，原先並不是爲了該估計方法而設計的。不過有一點可以肯定的是，這一方法在應用上有極大的潛力和價值，只要來自同一地區的樣本數目夠大，而且不同遊憩場所的各種特徵項目的水準也有相當的差異性，則一定能避免本研究所遭遇的問題。