Journal of Leisure Research
1999, Vol. 31, No. 4, pp. 404–419

Heterogeneous Visitors and the Spatial Limits of the Travel Cost Model

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Recently, a series of papers have attempted to accommodate the diversity of visitors in travel cost models by separating monetary outlays for recreation into two categories: on-site costs and long distance travel costs. One of the major motivations behind these on-site cost models is to solve the problem of spatial limits of the travel cost model identified by Smith and Kopp (1980). This paper empirically examines if the on-site cost model effectively deals with issue of spatial limits. Our findings indicate that serious spatial limits may still exist in the on-site cost model.

As a feasible remedy, we propose an alternative classification of visitors. Econometric implementation of this classification scheme with data from a survey of trout fishermen in the Greater Yellowstone Ecosystem suggests the approach both increases the explanatory power of the on-site cost model, and to a large extent, alleviates the spatial limits of the on-site cost approach.

KEYWORDS: *Travel cost, heterogenous visitors, Yellowstone National Park, travel cost, on-site cost, parameter stability*

Introduction

Accurately modeling heterogeneous visitors in recreation demand models is a complex issue that has received much attention. Recently, Randall (1994) listed a number of difficulties that afflict travel cost models and are also inherent in random utility models. These complications all arise from the researcher's inability to observe the prices of recreation site visitation, since these prices are likely to be endogenous. The allocation of joint costs, the price of substitute goods, and the value of time are somewhat unobservable to the researcher. For visitors traveling long distances these difficulties are particularly problematic. Indeed, the inaccurate observation of prices may be the source of the spatial parameter instability demonstrated by Smith and Kopp (1980).

Recently, however, a series of papers (Bell & Leeworthy, 1990; Shaw, 1991; Hof & King, 1992; McConnell, 1992; Larson, 1993) have attempted to accommodate the diversity of visitors by focusing on differences in the distance they travel. Some of these authors separate monetary outlays for recreation into two categories: on-site costs and long distance travel costs. We

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refer to these models as on-site cost models. The visitor is assumed to choose both the number of long distance trips to the site, as well as the number of days spent on-site. One of the major motivations (Bell & Leeworthy, 1990; Hof & King, 1992) behind these on-site cost models is as a solution to the spatial limits of the standard travel cost model identified by Smith and Kopp (1980).

This paper empirically examines if the on-site cost model, with its unidimensional focus on distance traveled as a measure of visitor heterogeneity, effectively deals with the spatial limits identified by Smith and Kopp. Our findings indicate that serious spatial limits still may exist in the on-site cost model.

As a feasible remedy, we propose a classification of diverse visitors based upon their total travel itinerary, rather than simply on distance traveled. Econometric implementation of this classification scheme suggests that for our application the approach alleviates the spatial limits of the on-site cost approach.

There are five remaining sections. The next section concisely presents the on-site travel cost model. In Section 3, we briefly discuss the GYE data and report the results of parameter stability tests. Section 4 contains our alternative classification of fishermen. The empirical implementation of this scheme is discussed in Section 5. We conclude in the last section.

Conceptual Framework

The On-site Travel Cost Model.

The on-site travel cost model is given by Hof and King (1992), who assume the recreationist minimizes expenditures

$$M = M\,(P_D, P_R, P_Y) = D^*P_D + R^*P_R + Y^*P_Y, \tag{1}$$

subject to a fixed utility level,

$$U^o = U(E, Y), \tag{2}$$

and produces recreation experience with the production function

$$E = f\,(R, D, Q_D, H), \tag{3}$$

where,

P_D = daily on-site cost of visiting the recreation site
P_R = cost of long distance travel to the recreation site;
P_Y = price of a composite good;
R = number of long distance trips to the recreation site;
D = number of days spent at the recreation site;
Y = a composite good;
Q_D = quality of the daily recreation site; and

H = a vector of recreation-related human capital measures. Minimizing (1) subject to (2) and (3) results in the expenditure function

$$M^*(P_D, P_R, P_Y, U^o). \tag{4}$$

Hicksian demand functions can be obtained from (4). The demand for days on-site is given by the $\partial M^*/\partial P_D$:

$$D^* = g\ (P_D, P_R, P_Y, U^o). \tag{5}$$

In equation (5) if P_D is large enough to drive D^* to zero, then the optimal number of long distance trips, R^*, will also be zero. If this is the case, the weak complementarity condition required to obtain welfare estimates using the on-site cost model is satisfied.

Separating travel costs into categories that break out costs incurred on-site provides several potential advantages.

1. Breaking survey questions regarding recreationists' expenditures into disaggregated categories will aid visitor recall and elicit more accurate answers about expenditures as a whole.
2. Days on-site can be used as a dependent variable in recreation demand equations, rather than number of trips. This avoids the common assumption of standard travel cost models that trips of different lengths have the same price (Hof & King, 1992).
3. Empirical evidence suggests that recreationists react differently to changes in on-site costs than to changes in long distance costs (Gibbs, 1974; Gibbs & Conner, 1973, Bell & Leeworthy, 1990). Finally, allowing separate price effects may eliminate the parameter instability found by Smith and Kopp (1980).

Although these potential advantages are appealing, their realization hinges upon the stability of parameter estimates. Parameter stability cannot be determined theoretically; rather empirical verification is required. Unstable parameter estimates would suggest that separating recreation costs into categories does not successfully deal with the problem of heterogeneous visitors. In the next section, we estimate an on-site cost model for GYE anglers and test the model for parameter stability.

Tests of Parameter Stability

Data Description.

The data used to test for parameter stability were obtained from 386 surveys completed by trout fishermen at five different sites in the Greater Yellowstone Ecosystem (GYE) in 1993. These five sites are representative of the world-famous, blue ribbon trout fishery that includes the headwaters of the Missouri, Yellowstone, and Snake Rivers (Kerkvliet, Nowell, & Lowe, 1995). Few, if any, good substitutes exist for these world-famous waters.

The survey contained three sections. The first section was completed by everyone, and asked for demographic information, current day expenditures, prior nights lodging costs (if any), distance traveled for the current days fishing, and money spent for the day's activities. All information regarding on-site costs (P_D) were taken from this section of the survey. Respondents who only filled out this section of the survey did not spend a night in the GYE.

The second section of the survey was completed only by respondents making an overnight stay in the GYE, but visiting no other major destinations. Here, respondents were queried about long distance travel costs from their home to the GYE.

The third section of the survey was completed only by respondents whose GYE visit was part of a multi-destination trip. These individuals were asked for their major destinations, prior to, and after leaving, the GYE. In addition, they were asked if their travel plans would have been significantly altered if they had not visited the GYE. Additional details about the survey and the construction of the variables used for estimation are provided in the Appendix.

Long distance travel costs to the GYE were separated from on-site costs differently for the three types of visitors. For all visitors, on-site costs are the summation of the prior nights lodging costs (if any), travel costs for the current day, and equipment and licence costs for their day of fishing. Thus, single day visitors had all costs associated with their visit allocated to on-site costs. Anglers who completed section two of the survey were making multi-day trips to the GYE, but to no other destinations. These individuals were assigned on-site costs in an identical fashion to single day visitors. Long distance travel costs were based on the cost of getting to the GYE from their home as explained in the Appendix.

Individuals who completed section three of the survey were visiting the GYE in the course of a multiple-destination trip. To classify these individuals we made use of responses to the question of whether or not their total driving distance changed due to their stop in the GYE. Individuals who indicated their long distance travel plans would not have changed if they had not stopped in the GYE were assigned zero long distance travel costs. If total trip length did increase because of the GYE visit, we calculated the increase in costs due to their GYE visit. Regardless of whether or not trip plans were altered by the GYE stop, we calculated on-site costs for these individuals in the same fashion as for all other visitors. Again, details are in the Appendix.

Descriptive statistics for the variables used in estimating the on-site cost model are given in Table 1. The dependent variable (LNDAYS) is the natural log of the number of days the angler spends fishing in the GYE between May and October. On-site costs are OSC, and long distance travel costs are TC. Demographic variables include age (AGE), GENDER (1 = male, 0 = female), marital status (MARRIED), number of children (KIDS), a variable measuring increasing levels of formal education (EDU), and annual expenditures for outdoor recreation (OREXP). We use OREXP as a proxy of income following Shaw's (1991) suggestion.

The angler's perception of her fishing skill (SKILL) is measured on a nine category Likert scale, with higher categories indicating greater per-

TABLE 1
Descriptive Statistics

Variable	Mean	Standard Deviation
LNDAYS	2.14	1.05
OSC	81.29	86.36
TC	443.89	459.19
PRIMP	.94	.23
AGE	43.76	14.43
CATCHRATE	.98	1.18
SKILL	7.04	2.09
NUMANG	18.16	15.72
KIDS	1.52	1.57
MARRIED	.68	.47
OREXP	1382.10	1555.6
GENDER	.93	.25
EDU	5.07	1.26
GALLATIN	.12	.32
SLIDE INN	.22	.41
YELLOWSTONE	.32	.41
CABIN CREEK	.05	.22

ceived skill. The other angler characteristic is a binary variable (PRIMP) equal to one if the primary purpose of the visit was fishing, and zero otherwise. The qualities of the different survey sites are the number of fish the angler reported catching divided by the number of hours she fished (CATCHRATE), the number of anglers encountered (NUMANG), and four dummy variables: GALLATIN = 1 for the Gallatin River, CABINCREEK = 1 for the Madison river near Cabin Creek, SLIDEINN = 1 for the Madison River near Slide Inn, and YELLOWSTONE = 1 for the Yellowstone River near Buffalo Ford inside Yellowstone National Park. Slough Creek, also inside Yellowstone National Park, is the referent site.

With these data, we estimate the following equation using OLS and, following Smith and Kopp (1980), perform CUSUM tests of parameter stability across the dimension of distance traveled.

$$\begin{aligned} \text{LNDAYS} = {} & \beta_0 + \beta_1{*}\text{OSC} + \beta_2{*}\text{TC} + \beta_3{*}\text{PRIMP} + \beta_4{*}\text{AGE} \\ & + \beta_5{*}\text{CATCHRATE} + \beta_6{*}\text{SKILL} + \beta_7{*}\text{NUMANG} \\ & + \beta_8{*}\text{KIDS} + \beta_9{*}\text{MARRIED} + \beta_{10}{*}\text{OREXP} \\ & + \beta_{11}{*}\text{GENDER} + \beta_{12}{*}\text{EDU} + \beta_{13}{*}\text{GALLATIN} \\ & + \beta_{14}{*}\text{SLIDEINN} + \beta_{15}{*}\text{YELLOWSTONE} \\ & + \beta_{16}{*}\text{CABINCREEK} + \varepsilon, \text{ where } \varepsilon \sim N(0, \sigma^2). \end{aligned} \tag{6}$$

The parameter estimates from equation (6) are presented in Table 2.

TABLE 2
Estimates On-Site Cost Equation

Variable	Coefficient	Absolute T-Statistic
CONSTANT	.747	1.690
OSC	−.0013	2.034
TC	.0004	3.507
PRIMP	.996	3.986
AGE	.012	2.501
CATCHRATE	.126	2.435
SKILL	.089	2.988
NUMANG	−.006	1.598
KIDS	−.103	2.296
MARRIED	−.282	1.910
OREXP	.00005	1.209
GENDER	−.154	0.649
EDU	−.105	2.177
GALLATIN	.067	0.332
CABIN CREEK	.313	1.141
YELLOWSTONE	.102	0.648
SLIDE INN		

$R^2 = .294$ ADJUSTED $R^2 = .248$ $F\,(16, 247) = 6.42$ $N = 264$

Our results are consistent with prior expectations. As predicted by theory, the coefficient on OSC is negative and significant at the .05 level. No theoretical prediction can be made on the sign of the coefficient associated with TC. Similar to Hof and King (1992) we find this coefficient to be positive. As one would expect, PRIMP, SKILL, and CATCHRATE are positively related to visitation. One other interesting result is that the coefficient on NUMANG, although negative, is not significant, indicating no strong relationship between crowding on the waterways of the GYE and visitation.

Other transformations of the dependent and independent variables produced results that did not differ substantively from those reported here. The semilog demand equation used here satisfies the weak complementarity condition (Hof & King, 1992), but has other implicit restrictions (see LaFrance, 1990).

CUSUM Tests

To judge whether the on-site approach mitigates the problems identified by Smith and Kopp (1980), we test for coefficient stability by conducting CUSUM and CUSUM SQUARED tests. The CUSUM test applies the properties of recursive residuals to test the null hypothesis of no structural change over a single dimension (Brown et al., 1975).

Since the on-site model is best suited to those traveling long distances, we sorted the observations in descending order of distance traveled. The results of the CUSUM and CUSUM SQUARED tests are shown in Figure 1. The straight lines represent the 95 percent critical values for the test of the null hypothesis that the coefficients are stable with regard to distance. As shown, the null hypothesis of stability is rejected using both tests. The tests indicate stability for distances of less than 200 and greater than 1800 miles. However, for distances between distances of 200 to 1800 miles, where the majority of the observations are located, coefficient instability is indicated. These results suggest that in our application, an on-site model which treats all visitors as homogenous cannot be correctly applied to visitors traveling diverse distances to a site.

The on-site cost model was developed, in part, to mitigate the problem of parameter instability for heterogeneous visitors. Our application shows this may not always be the case. It seems reasonable to suspect that part of the reason for this failure is that visitors differ across dimensions other than distance traveled. In extensive conversations with GYE anglers we learned that anglers differed markedly in the way that fishing fit in with their overall travel plans. In the following section, we recognize this and consider a classification scheme based on behaviors that reflect different types of GYE visits. Our classification scheme closely resembles that of Parsons and Wilson (1997) but may not be the only classification scheme that would reduce problems caused by visitor heterogeneity.

Classification of Visitors

We focus on three types of visitors: single-day visitors, single- destination tourists, and multiple-destination tourists.

Type I Visitors: Single-day Visitors

Single-day visitors visit the site for one day only, regardless of how far they traveled to the site. In most cases, these visits are local in the sense that they travel a short distance from home and return to their home the same day. In a few cases in our data, single day visitors flew into West Yellowstone, Montana, rented a car, fished a GYE site, and returned to their distant home in the same day. Even though the distances traveled are diverse, the behavior of these single-day visitors satisfies all the assumptions of the traditional travel cost model (Freeman, 1994). These visitors choose only the number of single day trips to the recreation site, and are influenced by P_D. For these visitors $R = 0$ and, since all expenditures are for the single days visit, P_R is irrelevant. Returning to the expenditure minimization problem from Section 2, the single-day visitor minimizes

$$M = M(P_D, P_Y) = D^*P_D + Y^*P_Y \qquad (1')$$

subject to equation (2), and produces the recreation experience via the production function

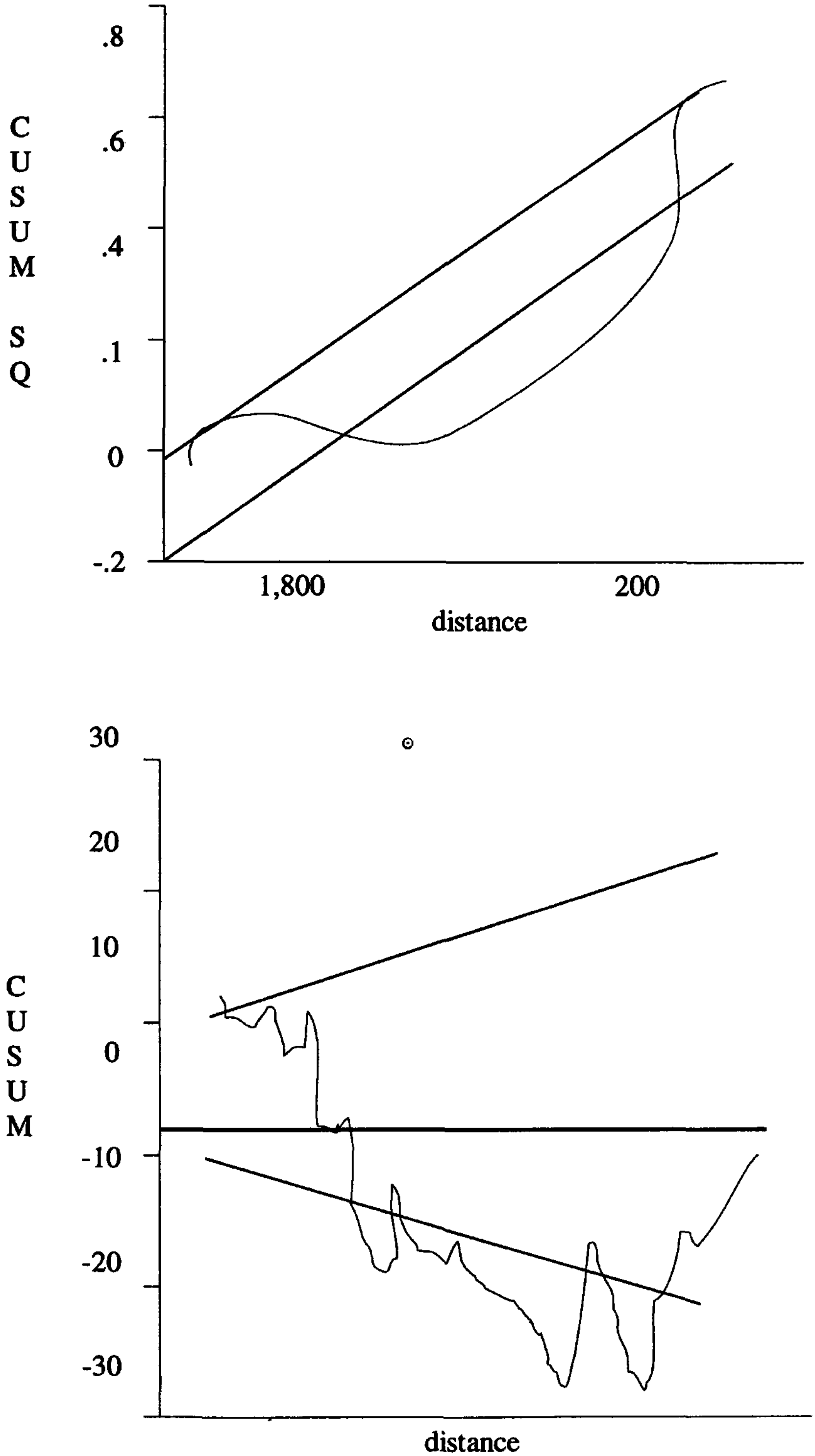

Figure 1. Tests of Stability on-site Cost Model

$$E = f(D, Q_D, H). \quad (3')$$

In this case, $E(\cdot)$ does not include R. The single-day visitor's Hicksian demand function for recreation days spent on site is given by

$$D^* = g(P_D, P_Y, U^o). \quad (5')$$

Type II Visitors: Single-destination Tourists

Single-destination tourists travel to a single site for multiple days. They pay a one time long distance travel cost (P_R) to get to the area and an on-site cost for each day's visit (P_D). The on-site costs are calculated in a similar fashion for Type I and Type II visitors, except Type II visitors pay a cost for the prior nights lodging.

Type II visitors must decide on both how many long distance trips to make to a site and how many days to spend at the site each trip. Type II visitors differ from type I visitors because for Type I visitors every trip to the GYE is equal to one day in the GYE. This is not true for Type II visitors. Because each long distance trip to the GYE involves an overnight stay the number of days spent in the GYE must be greater than the number of trips to the GYE. The behavior of the Type II visitor is accurately described by the on-site cost model. Consequently, the Type II visitor minimizes (1) subject to (2) and (3). The result of the minimization is the expenditure function (4), from which the Hicksian demand function (5) is obtained.

Type III Visitors: Multiple-destination Tourists

Multiple-destination tourists visit more than one destination in the course of a trip, including the GYE. Their travel behavior is different from that of Type I or Type II visitors who only visit the GYE. Allocating all long distance travel costs to the site visit is inappropriate in both the travel cost and on-site cost models. The overall travel itinerary of the tourist becomes paramount in correctly allocating these costs. Our survey allowed us to distinguish two cases.

Case A. This multiple-destination tourist stops at the site of interest while on the way to her primary destination. She indicated in the survey that her long distance travel costs were unaltered by her visit to the site. These visitors are similar to Type I visitors in that $R = 0$ and P_R is irrelevant. For example, an individual may drive from Wyoming to her primary destination, Glacier National Park. On her way she may drive by a site in the GYE, and without altering the primary itinerary of her trip, decide to stop. In this case, none of the long distance travel costs are accurately attributed to the visit to the GYE; rather long distance travel costs are only relevant because they reduce her income.

This multiple-destination visitor minimizes

$$\{M - A\} = M(P_D, P_Y) = D^*P_D + Y^*P_Y, \quad (1'')$$

where A is the expenditure on long distance travel to the primary destination, subject to (2). She produces recreation experiences via the production function

$$E = f(D, Q_D, H), \tag{3''}$$

which does not include R. The Hicksian demand function for this visitor is

$$D^* = g(P_D, P_Y, U^o). \tag{5''}$$

Case B. In contrast to Case A, this multiple-destination tourist alters her route to her primary destination in order to visit the site of interest. In this case, visitation to the site alters her long distance travel costs, and both PD. and PR are relevant. Because respondents provided information on their primary destinations before and after visiting the GYE it was possible to calculate the increase in mileage caused by the visit to the site. Only the cost of the additional mileage to the GYE should be allocated to the site. This cost should be treated differently from costs that would have been incurred to visit the primary destination.

Let NTC be the total long distance travel costs not allocated to the visit to the site. The visitor's problem now is to minimize

$$\{M - \text{NTC}\} = M(P_D, P_R, P_Y) = D^*P_D + R^*P_R + Y^*P_Y \tag{1'''}$$

subject to (2). The cost of long distance travel, PR, is the incremental cost of the visit. She produces the recreation experience via the production function

$$E = f(D, R, Q_D, H). \tag{3'''}$$

The Hicksian demand function for this type of multi-destination tourist is given by

$$D^* = g(P_R, P_D, P_Y, U^o). \tag{5''}$$

To illustrate Case B, consider an individual who lives in Denver, Colorado, and makes a 500 mile round trip to fish Utah's Green River. Each time the angler visits the Green River, an additional 450 mile round trip will buy a visit to the GYE. If the angler chooses to visit Yellowstone, only the cost of the additional miles traveled should be allocated to the GYE visit.

The usefulness of this classification scheme for the purpose of estimating recreation demand lies in its ability to separate recreationists into less heterogenous groups. In the next section, we test if our classification scheme significantly improves the explanatory power of the on-site travel cost model and test if our classification is able to eliminate the parameter instability identified by the CUSUM and CUSUM SQUARED tests.

Results

To test our classification scheme we use a series of dummy variables to separate Yellowstone anglers into the four groups discussed immediately above. Using Type I visitors as the baseline, we create three binary variables: TYPE2 =1 if the individual is a type II visitor and 0 otherwise; TYPE3A = 1 if the visitor is a Type III, Case A visitor and 0 otherwise; and TYPE3B = 1 if the visitor is a Type III, Case B visitor and 0 otherwise. Using this approach, we constrain the price coefficients to be identical for each group, but allow for different intercepts between groups.

The resultant regression equation is given by:

$$\begin{aligned} \text{LNDAYS} = {} & \beta_0 + \beta_1^*\text{TYPE2} + \beta_2^*\text{TYPE3A} + \beta_3^*\text{TYPE3B} \\ & + \beta_4^*\text{OSC} + \beta_5^*\text{TC} + \beta_6^*\text{PRIMP} + \beta_7^*\text{AGE} \\ & + \beta_8^*\text{CATCHRATE} + \beta_9^*\text{SKILL} + \beta_{10}^*\text{NUMANG} \\ & + \beta_{11}^*\text{KIDS} + \beta_{12}^*\text{MARRIED} + \beta_{13}^*\text{OREXP} \\ & + \beta_{14}^*\text{GENDER} + \beta_{15}^*\text{EDU} + \beta_{16}^*\text{GALLATIN} \\ & + \beta_{17}^*\text{SLIDEINN} + \beta_{18}^*\text{YELLOWSTONE} \\ & + \beta_{19}^*\text{CABINCREEK} + \varepsilon \end{aligned} \tag{7}$$

Results from estimating (7) are presented in Table 3. We were not able

TABLE 3
Estimates Revised On-Site Cost Equation

Variable	Coefficient	Absolute T-Statistic
CONSTANT	2.04	5.04
TYPE2	−1.46	7.52
TYPE3A	−1.74	8.70
TYPE3B	−1.77	8.40
OSC	−.0014	2.32
TC	.0006	4.17
PRIMP	.881	4.07
AGE	.016	3.60
CATCHRATE	.114	2.53
SKILL	.091	3.55
NUMANG	−.008	2.31
KIDS	−.117	3.02
MARRIED	−.184	1.44
OREXP	.00009	2.86
GENDER	−.222	1.07
EDU	−.100	2.38
GALLATIN	−.131	0.74
CABIN CREEK	.300	1.27
YELLOWSTONE	.126	0.93
SLIDE INN	.481	3.42

$R^2 = .484$ ADJUSTED $R^2 = .444$ $F\,(19, 244) = 12.04$ $N = 264$

to significantly improve these results by letting other coefficients vary by group type. All of the coefficients associated with the dummy variables are significant at the .01 level. As predicted by theory, the coefficient on OSC remains negative and significant at the .05 level. The overall R^2 of the regression improves from .294 to .484, and the adjusted R^2 increases from .248 to .444. In general, regression results from equation (7) appear to be much stronger than those from equation (6). The explanatory variable OREXP, a proxy for income is significantly related to visitation in equation (7), but was insignificant in equation (6). The coefficient on NUMANG, a variable measuring the influence of crowding on visitation is negative and significant in equation (7), and was insignificant in equation (6).

We calculated daily consumer surplus estimates at mean values for all explanatory variables. Although these estimates are sensitive to functional form, the resultant consumer surplus estimates are as follows: Type 1 visitors, \$1106.05; Type 2 visitors, \$439.98; Type 3A visitors, \$190.9; Type 3B visitors, \$186.19. The average daily consumer surplus for all groups is \$596.8. If we were to use the estimates from the traditional on-site cost model, given in Table 2, the mean daily consumer surplus estimate would be \$1,024. These consumer surplus estimates are similar to those reported by Duffield et. al. (1992) who obtained daily consumer surplus estimates (inflated to 1993 dollars) of \$225 for state residents and \$680 for out-of-state visitors in a study of the Big Hole river in Montana.

Chow Test

Because equation (6) is a restricted version of equation (7) we can conduct an F-test of the hypothesis of the null hypothesis that the restricted equation (6) has the same explanatory power of the unrestricted equation (7). The test statistic equals 5.30, which leads us to reject the null hypothesis at $p < .01$. This result indicates that the dummy variable scheme significantly improves the explanatory power of the equation.

CUSUM and CUSUM SQUARED Tests

To conduct the CUSUM and CUSUM SQUARED tests we once again sorted the observations in descending order of distance traveled. The results of the CUSUM and CUSUM SQUARED tests based on regression equation (7) are shown in Figure 2. Figure 2 is interpreted in an identical manner as Figure 1. The straight lines represent the 95 percent critical values for the test of the null hypothesis that the coefficients are stable with regard to distance.

Both the CUSUM and CUSUM SQUARED tests indicated parameter instability for distances between 200 and 1800 miles in the traditional on-site-cost model estimated with equation (6). Our model, which controls for visitor heterogeneity, reduces the parameter instability identified by the CUSUM test to distances between 200 and 600 miles. In addition, the

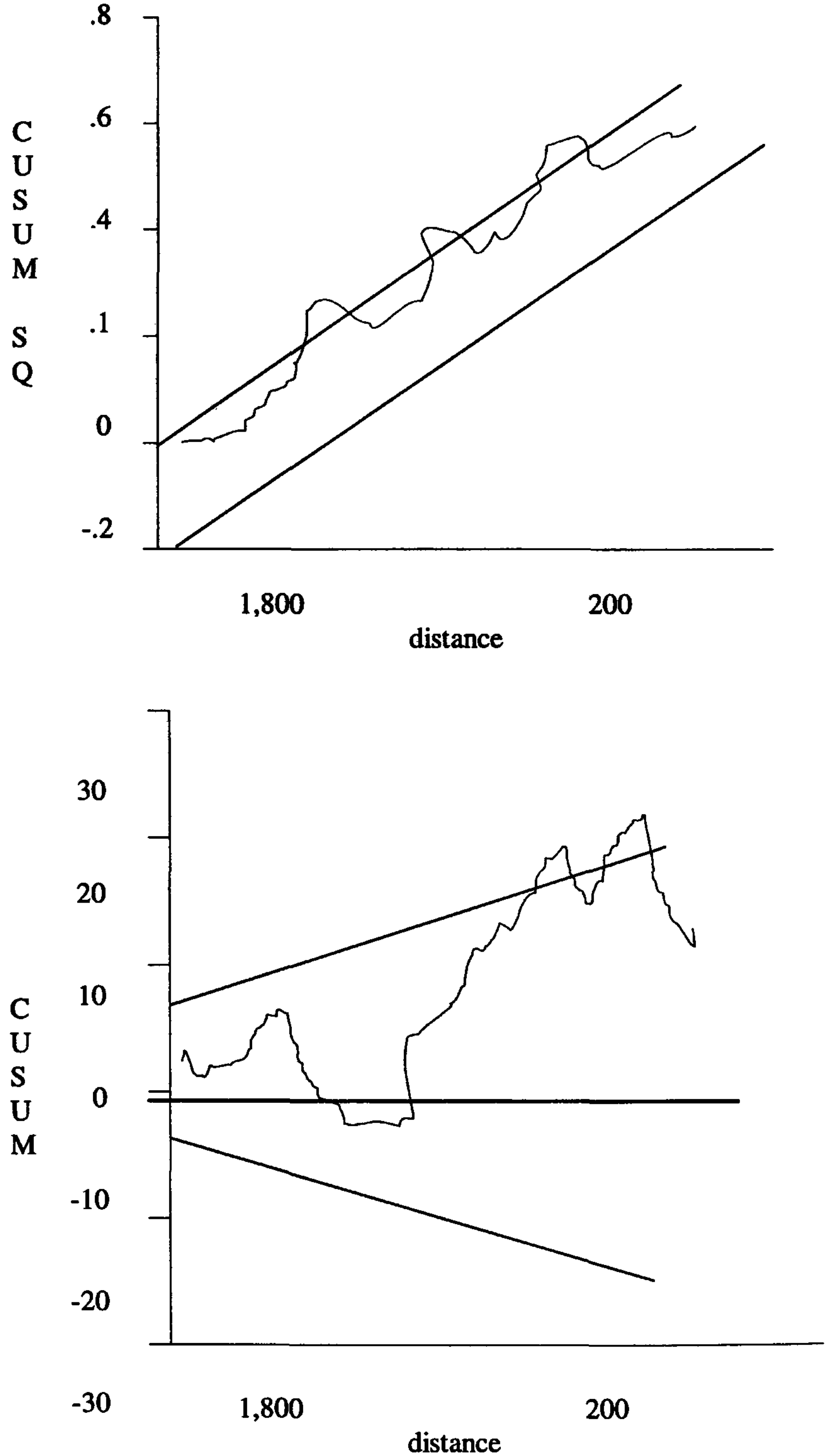

Figure 2. Tests of Stability Revised on-site Cost Model

CUSUM SQUARED test indicates parameter stability for all but three observations.

Conclusion

A recent set of papers (Bell & Leeworthy, 1990; Hof & King, 1992; Larson, 1992; McConnell, 1992; Randall, 1994) contains proposals to modify the travel cost model by separating on-site costs from long distance travel costs. One intention of these on-site cost models is to solve the well-documented spatial limitations found in traditional travel cost models (Smith & Kopp, 1980). Using a sample of Greater Yellowstone Ecosystem anglers, we find evidence that the on-site cost model does not eliminate parameter instability.

As a potential remedy, we propose a classification scheme based on the number of days the visitor spends at the site and the characteristics of her complete vacation itinerary. The explanatory power of our classification scheme is markedly greater than the explanatory power of the traditional on-site cost model. Also, our classification scheme is largely successful in eliminating parameter instability due to distance traveled. Our classifications are a synthesis of the wide variety of itineraries chosen by anglers visiting the blue-ribbon fisheries of the Yellowstone area. Different classifications may be appropriate for other recreation sites. Visitor heterogeneity has long been suspected as the root cause of parameter instability in travel cost analysis. We provide one possible framework to help control for this heterogeneity.

References

Bell, F. W. & Leeworthy, V. R. (1990). Recreational demand by Tourists for Saltwater Beach Days. *Journal of Environmental Economics and Management, 18:*189-205.

Brown, R., Durbin, J. & Evans, J. (1975). Techniques of Testing the Constancy of Regression Relationships over Time. *Journal of the Royal Statistical Society, 37:*149-63.

Duffield, J. W., Neher C. J. & Brown, T. C., (1992). Recreation Benefits of Instream Flow: Application to Montana's Big Hole and Bitterroot Rivers. *Water Resources Research, 28:* 2169-2181.

Franke, M. A., (1997). A Grand Experiment. *Yellowstone Science, 5:*8-13.

Freeman, A. M. III., (1993). *The Measurement of Environmental and Resource Values: Theory and Methods,* Resources for the Future.

Gibbs, K. C. & Conner, J. R. (1973). Components of Outdoor Recreation Values: Kissimmee River Basin, Florida, *Southern Journal of Agricultural Economics, 25:*239-244.

Gibbs, K. C.(1974). Evaluation of Outdoor Recreational Resources: A Note. *Land Economics, 50:* 309-311.

Hof, J. G. & King, D. A. (1992). Recreational Demand by Tourists for Saltwater Beach Days: Comment. *Journal of Environmental Economics and Management, 22:*281-291.

Kerkvliet, J., Nowell, C., & Lowe, S. (1995) The Economic Value of a Predator: Yellowstone Trout. *Greater Yellowstone Predators Conference,* Mammoth Hot Springs, WY.

LaFrance, J. T. (1990). Incomplete Demand Systems and Semilogarithmic Demand Models. *Australian Journal of Agricultural Economics, 34:*118-131.

Larson, D. M. (1993). Joint Recreation Choices and the Implied Value of Time. *Land Economics, 69:*270-286.

McConnell, K. E. (1992). On-Site Time in the Demand for Recreation. *American Journal of Agricultural Economics, 74:*918-925.

Parsons, G. R. & Wilson, A. J. (1997). Incidental and Joint Consumption in Recreation Demand. *Agricultural and Resource Economics Review, 26*:107-115.

Randall, A. (1994). A Difficulty with the Travel Cost Method. *Land Economics, 70*:88-96.

Shaw, W. D. (1991). Recreational Demand by Tourists for Saltwater Beach Days: Comment. *Journal of Environmental Economics and Management, 20*:284-289.

Shaw, W. D. (1992). Searching for the Opportunity Cost of an Individual's Time. *Land Economics, 68*:64-71.

Smith, V. K. & Kopp, R. J. (1980). The Spatial Limits of the Travel Cost Recreational Demand Models. *Land Economics, 56*:64-72.

U.S. Department of Transportation, (1984). *Costs of Owning and Operating Automobiles and Vans*, Washington. DC.

U.S. Department of Labor. (1992). *CPI Annual Report*, Washington, DC.

Appendix

During the summer of 1993, 1,100 surveys were distributed to trout fishermen at five different sites in the GYE. Surveying was done on 10 randomly selected days for each site between June 15 and August 15. Surveys were either handed directly to anglers on or near the rivers, or left on the windshields of cars at parking lots at the various sites. In either case, an introductory letter asked anglers to complete and return the surveys in a pre-addressed, stamped envelope. Surveying was done at two different locations on the Madison River in Montana, known locally as Cabin Creek and Slide Inn, as well as at three different sites within Yellowstone National Park: Slough Creek, the Gallatin River and the Yellowstone River. Anglers returned 386 (35 percent) of the surveys. Although this response appears low, we can detect no significant differences in catch rates, number of days spent visiting, and recreation expenditures, when our results are compared with person-to-person interviews conducted in the GYE two years later. In addition, the proportion of surveys returned from the sites within Yellowstone National Park are almost identical to the proportion of individuals the National Park Service reports fishing at these sites (Franke, 1997). The results reported in the text were obtained using the 264 surveys that were complete enough to construct the variables used for estimation.

The survey contained three sections. All anglers were asked to complete Part 1, which collected information on fishing quality, angler's demographic variables, travel cost, and on-site costs. Part 2 was completed by anglers spending multiple days in the GYE, but only visiting the GYE. Part 3 was completed by multiple day anglers who were also visiting destinations outside the GYE. Part 3 collected detailed information on the other destinations visited by the angler. Using this information we constructed the additional mileage resulting from the GYE visit.

Our sample consists angles arriving at the GYE by of commercial plane (27%), private cars (70%), or motor homes (3%). Costs per mile for private vehicles were calculated at $0.35 per mile for private cars, $0.47 per mile for cars pulling trailers, and $.53 for rental cars. These figures represent the costs of operating the vehicle (U.S. Department of Transportation, 1984) and are adjusted to June 1992 prices for transportation (U.S. Department of Labor, 1992). The cost of motor home operation included a base charge of $800, a rental fee of $0.16 per mile for any miles over 800, as well as gasoline costs of $0.12 per mile. These estimates were obtained from vendors of motor home rentals in the GYE area.

Regrettably, we did not directly ask anglers arriving by air about their airline travel costs; we only obtained information that gave distance traveled. Instead, we obtained a sample of actual air fares from 120 cities to Jackson, WY and Bozemen, MT, the two most likely airports used by anglers visiting the GYE. Using these data we estimated the following equation for air fares:

$$\underset{}{\text{Airfare}} = \underset{(4.14)}{280.9} - \underset{(1.74)}{146.3*\text{DUM}} + \underset{(4.15)}{.14*\text{ML}} + \underset{(1.14)}{.07*\text{DUM*ML}}$$

$$R^2 = .81, \quad F = 76.33, \quad N = 120,$$

where DUM = (0 or 1) depending on whether the trip was greater than or less than 1500 miles, ML is the one way mileage of the airplane trip. The variable DUM and its interaction with ML capture the effects of fixed costs and scale economies in the price of airline tickets. *T*-statistics are in parentheses. Fitted values for anglers' air fares were obtained by substituting the anglers' individual distance traveled into the above equation, based on their city of origin and other information about their travel plans.

Time spent on site was not assigned any monetary value. However, long distance travel costs were calculated to include the opportunity cost of time, based on the time spent on the road or in the air. For air travel, we assumed that one work day was lost (8 hours). For car travel, the opportunity cost is equal to the adjusted hourly wage multiplied by the hours spent on the road, calculated as the trip distance divided by 50 miles per hour. Individual income was calculated as household income divided by the number of wage earners and then multiplied by 2/3 for males and 1/3 for females. From this number, the hourly wage was calculated by dividing by 1920, the number of hours worked annually. To account for fixed incomes and paid vacations, the hourly wage was then adjusted by a factor of 2/3 (Shaw, 1992).