Endogenous On-Site Time in the Recreation Demand Model

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May 1999

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American Agricultural Economic Association Annual Meeting, August 8-11, 1999, Nashville, Tennessee

ABSTRACT

Careful modeling of on-site time may substantially improve estimates of the benefits of recreational visits using the travel cost method, especially when on-site time is endogenous. This paper reviews the theory of endogenous on-site time, and shows how the theory may apply to the Random Utility Model (RUM). An empirical example of sport fishing in Southcentral Alaska under varying specifications of on-site time is presented.

INTRODUCTION

Time spent on-site has the potential to confound estimates of non-market value of recreational visits because it carries both benefits and costs. Careful modeling of on-site time provides an opportunity to improve modeling of recreational demand based on the travel cost method, especially when on-site time is endogenous. In this paper we review the theory of endogenous on-site time in the travel cost model and show how the theory may apply specifically to the Random Utility Model (RUM).

The literature on recreation demand contains relatively little discussion of the issues surrounding treatment of on-site time. Smith, Desvouges, and McGivney (1983) develop a model in which on-site time is an endogenous component of the cost of a trip to a site. The central problem with interpretation of their simultaneous system for estimating trip demand is that the utility of the trip may vary directly with on-site time, in addition to varying indirectly due to the effect on trip cost. Identification in the Smith, Desvouges, and McGivney model is therefore problematic.

If on-site time is exogenously determined, however, explicit modeling of on-site time is straightforward. Kealy and Bishop (1986) discuss the case where on-site time is exogenous and constant across all households. Larson (1993) develops a model in which the recreationists simultaneously choose total time and the number of trips. Implicit in this joint choice, given an exogenous travel time, is a choice of average on-site time. Larson restricts preferences by assuming that the marginal value of travel time and marginal value of on-site time is equal. This assumption, while plausible for modeling demand for visits to a single-site over an entire season, fails for recreationists who choose each period from among several site options, each with varying characteristics and travel times.

McConnell (1992) provides a succinct treatment of the theoretical role time plays in the recreational demand model. Smith (1990) further elaborates issues related to on-site time employing the same general modeling framework. In the McConnell-Smith model, the consumer plans a series of recreational activities over a season or a year. He or she chooses the number of trips to each site, time to spend on-site during each visit, and consumption of other goods. However, their model did not discuss structural demand equations, and in particular the possibility of identification of on-site time in the trip demand equation. Their model is actually a "reduced-form" specification of an implied structural equation system.

One advantage of identifying and estimating a set of structural equations would be the added information the structural parameters provide about the role of on-site time in generating utility from the recreational activity. Even if the analyst does not desire information about the structural coefficients, identifying a set of structural equations for trip demand and on-site time may be needed to estimate trip costs properly.

A STRUCTURAL MODEL OF ON-SITE RECREATION DEMAND

In the multiple-site version of the model, the consumer chooses the number of trips to each site i, n_i, on-site time, t_i, and the level of consumption of other goods. The recreationist's maximum (indirect) utility is given by:

$$V(p,g,y,t,T,z) = \max_{n,t,x,q} u(n,t,x,q,z) - \lambda\left(\sum_{i=1}^{S}\left(p_i^{\,n} + p_i^{\,o}(t_i)\right)n_i + x - y\right) - \mu\left(\sum_{i=1}^{S} n_i(t_i + g_i) + q - T\right)$$

(1)

where:

V = indirect utility

n = number of trips

t = on-site time (hours)

g_i = travel time to site i

x = Hicksian good with numeraire price of 1 and no time cost

q = good which costs time but not money with numeraire time price of 1

y = income

T = total time except for work hours

p_i^n = money cost of travel to site i

$p_i^o(t_i)$ = money cost expended per hour of on-site time at site i

z = the quality of the recreational experience at a site.

There are S alternative sites: p^n, p^o, n, t, z, and g are vectors with dimension S.

Assume now that the total money cost expended at site i, p_i^o has a component p^* that is independent of time, and a component that varies with on-site time. That is, $p_i^o(t_i) = p^* + p^t(t_i)$. We assume, just for convenience of exposition, that p^t and p^* do not vary across sites. The demand for trips is derived using the envelope theorem from Roy's identity as:

$$n_i(n, t, x, q, z) = -\frac{\partial V / \partial p_i}{\partial V / \partial y} \tag{2}$$

where p is a vector with dimension S whose elements are $p_i = p_i^n + p_i^o(t_i)$.

For consumers at a corner solution in the labor market, the demand for trips depends on travel time vector, g, on-site time vector, t, trip prices (including on-site time costs), p, exogenous shift factors, z, total income, y, and total time, T. For consumers who can vary their work hours, one adds the cost of time to the trip price to reflect the full income constraint. That is,

$$p_i = p_i^n + p_i^o(t_i) + w(g_i + t_i) \tag{3}$$

Endogenous On-Site Time in the Random Utility Model

The Random Utility Model (RUM) presents a special case of the trip demand equation. RUM involves a number of restrictive assumptions about consumer demand that affect the treatment of on-site time. Under the assumptions of RUM, the utility of selecting the ith alternative is:

$$V_i(p_i, g_i, y, t_i, T, z_i) = V^1(y - p_i) + V^2(g_i, t_i, T, z_i) + \varepsilon_i \tag{4}$$

The assumption in RUM of a constant marginal utility of income implies that the Hicksian bundle of market consumption goods, x, does not appear as an argument of V[1].

If the random component of utility, ε_i, has the type one extreme value error structure, then the probability that alternative i will be selected is the familiar multinomial logit:

$$\pi_i = \frac{e^{V_i}}{\sum_{i=1}^{S} e^{V_i}} \tag{5}$$

where V_i is given by equation (4). A subscript for the time period (choice occasion) is implied in equation (5) and subsequent equations, but left out for ease of exposition.

The property of "independence of irrelevant alternatives" (IIA) assumption of the logit model follows from the fact that p_k has no effect on V_i/V_j $(k \neq i \neq j)$. That is, $\partial V_i(p_i, g_i, y, t_i, T, z_i)/\partial t_j = \partial V_i(p_i, g_i, y, t_i, T, z_i)/\partial g_j = 0:$ j = 1,2,...,,i-1, i+1,...,S.

Just as RUM assumes that the recreationist minimizes trip cost to the site, we assume each alternative has a unique on-site time that maximizes utility for that choice, if it is selected. In the nested RUM model, the assumption of IIA with respect to time, as well as price, holds only among alternatives within a given nest.

The assumption of $\partial V_i/\partial t_j = 0$ provides a sufficient number of restrictions on the coefficients of equations (4) and (5) to identify a structural relationship for on-site time for a given trip to each of the alternative sites. The following illustrative example provides a simple and flexible solution, based on the assumption that optimal on-site time on a particular trip to site i is not influenced by the number of trips.

An Illustrative Example

Suppose we assume a two-level nested discrete choice structure. At the upper level, recreationists decide their level of participation during a given period. At the lower level, they choose from a set of alternative sites. Equation (5) provides the probability of selecting site *i* on a given trip.

Suppose additionally that we assume that V^2 is a linear function of *g*, *t*, *T*, and *z*. Then an example of the RUM with full a model of time would estimate equation (5) with the following equation for V_i:

$$V_i = \alpha(y - p_i) + \beta(1-h)g_i + [\gamma_1 h + \gamma_2(1-h)]t_i + \delta z_i + \varepsilon_i \tag{6}$$

where *h* is a dummy variable equal to one if the consumer could vary work hours and equal to zero if work hours could not be varied.[1] The price of the trip to alternative *i*, p_i, is given by

$$p_i = p_i^{\,n} + p_i * + p_i^{\,t} t_i + wh(g_i + t_i) \tag{7}$$

where p_i^n is the money cost of travel to the site, $p*$ is the exogenous (fixed) component of on-site time, and p_i^t is the (constant marginal) cost of a unit of on-site time. Equations (6) and (7) reflect the imposed constraint that consumers who can vary their work hours value the marginal cost of travel time at their marginal earnings rate.

When on-site time is exogenous, one simply estimates $V_i(p_i, g_i, t_i, h, w, z_i)$ from equation (6), with p_i given by equation (7). Welfare implications follow those discussed by McConnell for exogenous on-site time. If a regression of on-site time on the right-hand-side variables in equation (6) indicates that on-site time is endogenous, then one proceeds exactly as with the exogenous case, except that on-site time t_i should be replaced by appropriate instrumental variables. Although on-site time to a particular site, t_i, is not simultaneously determined with the total demand for trips, it is simultaneously determined with the cost of the trip to that site. Failure to use instrumental variables for on-site time will produced biased estimates of the coefficient, resulting in biased estimates of willingness to pay.

EMPIRICAL APPLICATION

We tested how the specification of on-site time affects results of a discrete-choice travel cost model in an application based on data from mail and telephone surveys of 550 Southcentral Alaska sport fishing households. The abundance and diversity of sport fishing opportunities in Southcentral Alaska combined with favorable access provide sport anglers with unparalleled choices for high quality fishing experiences.

A random-digit-dial telephone survey of Alaska households conducted in May-June 1993 found that about 70 percent of the households in the Southcentral region had at least one sport angler. These 550 sample sport fishing households were re-interviewed in the fall, providing weekly data on the number and location of all sport fishing trips taken over a 27-week period, from April 29 to November 3, 1993. Survey households completed logs for 1298 randomly selected trips, providing trip-specific travel time and on-site time, as well as expenditures on transportation, food, lodging, bait and tackle, and guide and charter services.[2]

Results

Table 1 shows the estimated coefficients for a set of site-choice equations based on the specification given in equation (6), with the price of the trip specified as in equation (7). The equation was estimated for the 1,291 trips for which data were complete. The trip cost variable is the sum of transportation costs, estimated food, lodging, bait, and guide expenditures, and lost income for those who could have worked during their travel and on-site fishing time.

The site-choice equation coefficients in Table 1 appear generally plausible, with trip cost and travel time (for anglers who could not have worked) coefficients negative and strongly significant. A series of variables representing quality of fishing for a variety of species have positive and significant coefficients. The variables *Silver*, *Sockeye*, *Pinkchum*, *Trout*, and *Dolly* represent relative annual site productivity for these species. Close regulation of king salmon fishing and rapid migration of sockeye salmon to spawning areas prevent sport anglers from depleting these species, so their annual average catch rates (*Kingdf*, *Sockdf*) -- but not those of other species -- may also be considered exogenous. The variables *Halipeak*, *Kingrept*, and *Ksonar* reflect patterns of seasonal abundance for theses species at various sites, while variation in *Troutbag* largely reflects the effects of catch and release fishing restrictions. The diverse way in which fishing quality is measured across sites reflects the diversity of sport fishing opportunities available in Southcentral Alaska. In addition, the equations suggest that anglers value sites with campgrounds, uncrowded sites, and a popular derby fishery.

The first column of the table shows equation (6) estimated with on-site time assumed to be exogenous.[3] In the exogenous specification, the coefficient on on-site time when the angler could not have worked (*Nifhours*) is positive and significantly larger than when the angler could have worked (*Yifhours*). However, this result is not robust to the specification of on-site time.

When on-site time is replaced by its instrumental variable (column 2) , the coefficient on *Nifhours* shifts from significantly positive and larger than the coefficient on *Yifhours* in the exogenous-time equation to significantly negative and smaller. The main reason for the shift is that the structural variables for trip cost and on-site time take into account the correlation of on-site time with the angler's travel time and travel costs for alternative sites not selected by the angler. When on-site time is specified correctly, the equation suggests that the marginal value of on-site time is higher for anglers who could be earning income with that marginal hour compared to those who are not able to earn anything. This result provides support for the assumption that the opportunity cost of time differs for those anglers who are not at the margin on their labor supply schedules.

CONCLUSION

There are two reasons why researchers might want to take advantage of this opportunity. First, the coefficients of the structural equation provide useful information about the structure of preferences and economic behavior -- e.g., the role of on-site time in generating utility from a recreational activity. We found in the Alaska sport fishing example that the estimated marginal utility of on-site time for anglers who could not have been earning income was significantly negative and lower than that of anglers who could have worked. The structural estimates support the hypothesis that recreationists at a corner solution in their time budgets have significantly different opportunity costs of time from those at an interior solution.

Second, the over-identifying restrictions embedded in the structural equation may make it asymptotically more efficient for estimating the welfare effects of policy. It is not necessary to estimate a structural equation involving on-site time. Doing so, however, provides an alternative consistent estimate of compensating variation that arguably better predicts the effects of policy changes.

Modeling a structural endogenous relationship for on-site time is relatively straightforward in the RUM model. We suggest that researchers approaching applied problems for which on-site time is relevant should attempt to collect appropriate data on recreationists' on-site time and consider carefully how they use it in empirical analyses.

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Table 1: Site-Choice Equations with Three Specifications for On-Site Time

(t statistics in parentheses)

Variable	Exogenous	Structural
Tripcost	-0.003757 (-6.935)	-0.002997 (-7.589)
Travtime	-0.1161 (-8.798)	-0.1023 (-8.988)
Nifhours	1.0711 (6.142)	-0.1680 (-2.836)
Yifhours	0.6326 (3.194)	0.02590 (0.351)
Silver	0.00001679 (6.012)	0.00001814 (6.382)
Sockeye	0.000005149 (4.833)	0.000004728 (4.444)
Pinkchum	0.00003322 (2.394)	0.00003035 (2.188)
Trout	0.000007873 (4.651)	0.000005041 (2.660)
Dolly	0.000006484 (4.144)	0.000007989 (5.154)
Kingdf	1.5715 (7.119)	1.5556 (7.154)
Sockdf	0.4719 (6.784)	0.5081 (7.154)
Kingrept	0.09373 (5.250)	0.1002 (5.587)
Ksonar	0.002292 (3.385)	0.002035 (3.000)
Halipeak	1.0799 (9.691)	1.3533 (10.229)
Troutbag	0.1334 (7.753)	0.1558 (8.410)
Campgr	1.6780 (1.760)	1.7268 (1.813)
Crowding	-1.8033 (-1.769)	-1.7199 (-1.686)

Sewdby	0.6769 (2.773)	1.1289 (3.618)
Number of trips	1,291	1,291
Log-likelihood	-3797.6	-3804.2
Initial (slopes=0)	-4390.9	-4390.9
Chi-Squared	1186.6	1173.4

Definition of Variables for Tables 1.

$Travtime_i$: travel time to get to the *i*th site for those who could not have worked

$Nifhours_{it}$: on-site fishing hours of anglers who could not have worked (instrumental variable for structural equation)

$Yifhours_{it}$: on-site fishing hours of anglers who could have worked (instrumental variable for structural equation)

$Trout_i$: expected total annual catch for trout at the *i*th site (total harvest for previous year) when fishery is open, zero otherwise.

$Dolly_i$: expected total annual catch for dolly varden at the *i*th site (total harvest for previous year)

$Kingdf_i$: expected average fishing quality for king salmon at the *i*th site (total harvest divided by angler-days for the previous year at the *i*th site) when fishery is open, zero otherwise.

$Sockdf_i$: expected average fishing quality for sockeye salmon at the *i*th site (total harvest divided by angler-days for the previous year at the *i*th site) when fishery is open, zero otherwise.

$Kingrept_{it}$: fishing quality index for king salmon at the *i*th site in week *t* as published in the *Anchorage Daily News*. The data are reported in a linear chart with six levels, from poor to excellent. Zero indicates no fish being caught, or closed to king fishing.

$Silver_i$: expected annual total catch for silver salmon at the *ith* site (total harvest for the previous year at the *i*th site) when silvers are available and the fishery is open, zero otherwise.

$Sockeye_i$: expected annual total catch for sockeye salmon at the *i*th site (total harvest for the previous year).

$Ksonar_{it}$: Kenai River sockeye salmon sonar count site that week.

$Pinkchum_i$: expected annual total catch for pink or chum salmon at the *i*th site (total harvest for the previous year) when pinks or chums are available and the fishery is open, zero otherwise.

$Halipeak_{it}$: halipeak=1 if halibut during weeks of peak halibut fishing quality at the *i*th site in week *t*, otherwise halipeak=0, as published in ADF&G sport fishing brochures.

$Troutbag_{it}$: bag limit for trout at the *i*th site in week *t*. Zero indicates catch and release only.

$Campgr_i$: campgr=1 if a camp ground is available at the site, otherwise campgr=0.

$Crowding_{it}$: crowding=1 if the ith site is crowded in week t, otherwise crowding=0.

$Sewdby_{it}$: sewdby=1 for Resurrection Bay during the Seward silver salmon derby, otherwise sewdby=0.

Footnote

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[1]. Equation (6) does not include a term in total time, *T*. However, since *T* is constant, no information is lost by excluding it from the equation.

[2]. Trip logs included the following two questions: "How many hours did it take to get to the fishing site?" and, "How many hours did one or more household members fish at this site?" Households were also asked how many people went on the trip and how many people fished each day.

[3]. The food, lodging, bait, and guide components of the trip cost variable, as well as income losses for those who could have earned income on the trip, require assumptions about on-site time. When on-site time was specified as exogenous, we used the average value of on-site time in survey trips to that particular site.