Conjoint Analysis of Deer Hunting

John Mackenzie

This paper develops a logit-based conjoint analysis of willingness to pay for individual attributes of deer-hunting trips. Since deer-hunting success is uncertain, willingness to pay for enhanced likelihood of bagging a deer, rather than for certain success, is evaluated. Implicit costs of recreational travel time are also evaluated from hypothetical trade-offs between travel time and trip expenditures. The valuation of travel time derived here appears to reflect more the opportunity cost of foregone hunting than the opportunity cost of foregone work. This implies that travel-cost analyses of recreational demand, which impute costs of recreational travel solely from wage data, can yield biased valuations of recreational amenities.

This paper analyzes hunters' willingness to pay for various attributes of deer-hunting trips. In general, recreational trips are composite goods, and several issues related to the composite-good aspect of hunting are addressed. The first issue, which is particularly important in travel-cost analyses of recreational demand, involves the valuation of recreational travel time. Where travel-cost analyses fail to account for costs of travel time, valuations of recreational amenities are clearly understated (Cesario; Gum and Martin). While conventional travel-cost models impute opportunity costs of recreational travel time from wage data, it is clear that such opportunity costs also reflect recreationist choices between nearer, lower-quality recreation sites versus more-distant, higher-quality sites. The valuation of recreational time is at least partly endogenous to the broader recreation-valuation problem.

Second, hunting and hunting success appear to be distinct, albeit interrelated, arguments in hunters' utility functions. Hunting trips and hunting success may be viewed as joint products in a household production system (McConnell 1979; Bock-stael and McConnell) or as different attributes of a composite recreational good to be evaluated via a hedonic travel cost approach (Brown; Brown and Mendelsohn). Although such approaches add significant complexity, distinct valuations of hunting trips and hunting success may be of considerable value in refining game management strategies.

Third, the valuation of deer hunting is somewhat complicated by the low rates of hunter success. For example, in contrast to the success rates of waterfowl and small-game hunters, the survey data analyzed below indicate that most deer hunters in Delaware do not actually bag any deer in a typical season. It seems preferable to model deer-hunting behavior as motivated more by perceived probabilities of hunting success than by actual success. This paper develops a conjoint-measure approach, related to contingent valuation via referendum (Bishop and Heberlein; Hanemann; Cameron) to evaluate individual attributes of deer-hunting trips, including the likelihood of bagging a deer on a given hunting trip, and the implicit costs of travel time and site congestion. Survey respondents' comparative ratings of alternative hypothetical trips, described as attribute bundles, are analyzed to identify potential trade-offs between various attribute levels which leave respondents indifferent. When trip cost is included as a hunting-trip attribute, Hicksian willingness-to-pay measures for other trip attributes can be estimated from potential trade-offs between changes in trip cost and changes in other attribute levels that leave trip ratings unchanged.

The Valuation of Travel Time

Development of methods for evaluating demand for recreational amenities has proceeded along two paths, nonmarket and related market. The principal nonmarket method is contingent valuation, which involves the use of hypothetical questions to ascertain welfare changes associated with discrete changes in amenity levels. Related-market approaches involve imputing amenity values by observing how variations in amenity levels influence

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recreational travel (the travel-cost method), local property values (the hedonic pricing method), or household expenditures generally (the household production method) (Freeman).

The travel-cost approach is the most commonly used related-market method of analyzing demand for recreational amenities. One of the most intensively studied issues in the travel-cost literature has been the valuation of the opportunity cost of travel time (Cesario; McConnell and Strand; Wilman; Bockstael, Strand, and Hanemann). The issue may be sidestepped by treating miles traveled as a trip pseudoprice and estimating demand in terms of miles rather than dollars, but such valuations lack comparability with dollar valuations in other markets. More often, the time-valuation problem is framed as a trade-off between work and leisure. Time in transit between home and the recreational site is often evaluated at the hourly wage rate equivalent (e.g., Ross, Stevens, and Alien) or at some fraction thereof (e.g., Cesario).

A major complication is that labor-market rigidities commonly distort labor/leisure trade-offs. Bockstael, Strand, and Hanemann point out that, in econometric terms, the true labor/leisure margin is censored, and the true opportunity cost of time at the labor/leisure margin does not generally equal the hourly wage equivalent. Bockstael, Strand, and Hanemann apply conventional limited dependent variable techniques (e.g., Heckman) to improve the time-valuation estimate at the labor/leisure margin.

This paper takes an alternative view of the time-valuation problem. If a hunter's time is divided into hours at the hunting site, hours in transit to the hunting site, and other hours including work (Figure 1), there are actually two margins at which the opportunity cost of recreational trip time can be evaluated: at the start of the trip to the recreational site, and at the point of arrival at the recreational site. Where the labor/travel-time margin is uncensored, an increase in travel time will tend to displace both work time and time on site; where that margin is censored, increased travel time will usually displace time on site only. In effect, labor-market rigidities tend to force the time trade-off to the other margin, where additional recreational travel displaces time at the recreational site.

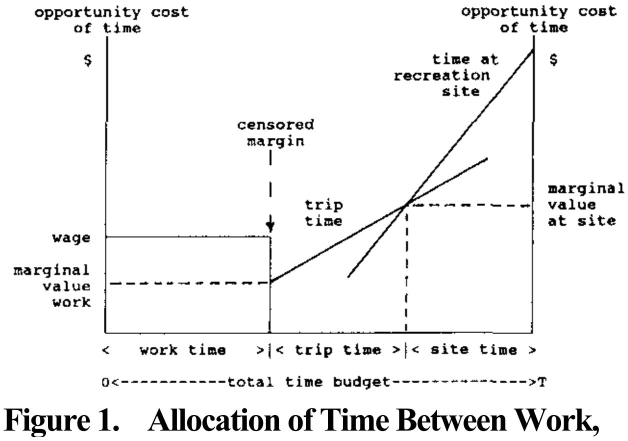

Figure 1. Allocation of Time Between Work, Recreation, and Recreational Travel

The marginal valuation of travel time need not be the same at both margins. Given a fixed amount of recreational time, a hunter can be viewed as choosing the hunting site and distance he or she will travel to it so that the marginal cost of travel, including the extra time on site foregone, matches the marginal benefit (higher-quality hunting). While the labor/leisure trade-off is exogenous to the choice of recreational site, but censored, the travel-time/time-on-site trade-off is unconstrained, but endogenous, to the choice of recreation site. The analysis below develops a conjoint approach to analyzing hunter preferences for alternative hunting trips and then examines whether marginal valuations of travel time in this analysis are sufficiently different from hourly wage equivalents to indicate that hunters' preferences for hunting trips do in fact reflect valuations of time at the travel-time/time-on-site' margin.

Conjoint Measure and Contingent Valuation

The contingent valuation method (CVM) is widely used in the valuation of wildlife amenities (HammacK and Brown; Bishop, Heberlein, and Kealy; Boyle and Bishop). In conventional open-ended applications, hypothetical bids are elicited from respondents regarding their willingness to pay, or willingness to accept compensation, for discrete changes in an environmental amenity. CVM's theoretical foundations in, and consistency with, welfare theory are well established (Maler; McConnell 1990). The hypothetical bids are identifiable as compensating-variation or equivalent-variation welfare measures.

The empirical shortcomings of the open-ended CVM approach are equally well known (Freeman; Schulze, d'Arge, and Brookshire; Bishop and Heberlein). Problems include biases caused by the framing of survey questions, information biases, strategic biases, and payment-vehicle biases; the lack of a definable general standard of accuracy; and the issue of consistency of contingent bids with valuations obtained via other methods. The past decade has seen a shift away from the open-ended approach, where respondents are asked to state willingness to pay for specified situations themselves, and toward a closed-ended referendum approach, where respondents are asked whether they would pay an amount specified by the researcher (Bishop and Heberlein). The latter approach minimizes starting-point bias but is significantly costtier in terms of observations required to estimate a demand schedule for a recreational amenity. These are generally estimated via multinomial logit (Hanemann 1984; Cameron and James).

The conjoint method used in this paper is basically a modification of the referendum CVM. This method, developed by Luce and Tukey in the psychometrics literature and commonly used in marketing research (Green 1974; Green and Srinivasan; Green, Carroll, and Goldberg; Gineo), involves decomposing a composite good into its constituent attributes, surveying respondents regarding their relative preferences for alternative attribute bundles, and quantifying marginal rates of substitution between attributes. One conceptual difference between conjoint measure and contingent valuation is that the price of the good is treated as simply another component attribute of the good.

Let *Z* represent a good with *N* attributes, so that Z = (zi, . . . , z/v), where z, refers to the quantity of the /th constituent attribute. If utility *U[Z(z{,* . . . , z/v); *X]* is weakly separable in *Z* and its component attributes, the marginal rate of substitution between any pair of attributes is independent of the consumption level of any other goods, *X.* Let two attributes, z, and z,-, be varied across alternative bundles 2° and Z^1 while all other attributes are held constant, and let consumers compare bundles Z°(. . . z,°, z,° . . .) andZ'(. . . z,^{1}, z,-^{1} . . .). Where these attributes are varied so that consumers are indifferent between Z° and Z^1_t the marginal rate of substitution between z/ and z_y- is U_{Zi}/U_{Zj} (Goodman).

In conventional marketing applications of the conjoint method where Z is a market good and P_z, the price of Z, is incorporated into the attribute bundle, consumers compare bundles Z°(. . . z/°, . . . P_z°) and Z'(. . . z,^{1}, . . . P_2^1). If only z/ and P_z are varied, and consumers are indifferent between Z° and Z^1, the ratio U_{Zi}/Up_z represents the marginal willingness to pay for attribute z,-. This is clearly a compensated measure, since utility is held constant.

Choices of Z may be made ex ante to maximize expected utility, denoted as *V[Z\ - E(U[Z\).* The expected utility function V[Z] has a systematic portion, vfZ], and an unobservable portion, *e,* so that expected utility from any bundle Z^1 is

$$V[Z^i] = v[Z^i] + e^l, \tag{1}$$

where *v[Z]* represents a specified functional form and *e'* represents a random disturbance. The usual referendum CVM approach involves asking respondents to indicate which of two paired bundles they prefer. If Z^1 is preferred to Z°, this implies

$$v[Z^1] > v[Z^0]. \tag{2}$$

Therefore, the probability that Z^1 will be chosen over Z° is

$$\text{Prob}\{v[Z'] > v[Z^\circ]\} - \text{Prob}\{(e' - e^\circ) < (v[Z^1] - v[Z^\circ])\}. \tag{3}$$

After selecting an appropriate functional form (e.g., normal or logistic) for the cumulative distribution of(e' - *e°),* the systematic portion of the expected utility function can be estimated as specified.

Where multiple bundles are to be compared, it is informational ly more efficient for respondents to rank a small number of bundles simultaneously rather than to make sequential pairwise comparisons. A respondent's rankings of *n* bundles implies *n(n* - 1)/2 nonredundant pairwise comparisons. The likelihood that respondents may give inconsistent rankings increases as *n* gets large, however. The utility function can be estimated via conventional binary-choice methods using *n(n* - 1)/2 pairwise choice observations per respondent, or via rank-order logit (Harrell) using *n* rank observations per respondent.

A variant of the ranking approach is to solicit qualitative ratings of bundles on a specified scale, 1, . . . , *k,* where (usually) *k> n.* For the analysis below, for example, respondents were asked to rate alternative bundles using a familiar "scale of 1 to 10, where 1 means completely unsatisfactory and 10 means ideal." Assuming each respondent's ratings are logically consistent, the ratings provide at least as much information about respondent preferences as ordinal rankings since they also provide some indication of intensity of preferences. Respondents can use equal ratings to indicate indifference between bundles. As the number of bundles to be rated increases, the rating approach would seem to be less likely to elicit inconsistent rankings than would the ranking approach.

While the ordinal significance of ratings is clear, their cardinal significance is not (Madansky). For example, if a respondent gives bundle Z° a rating of 8 and bundle Z a rating of 4, this does not imply that the respondent is indifferent between one bundle of Z° and two bundles of Z^1. Furthermore, ratings are not really continuous variables since their variation is restricted to the rating scale defined by the researcher. Furthermore, estimating ratings as functions of the various attribute levels via ordinary least squares (OLS) yields asymmetrically truncated residuals and biased coefficients. The correct procedure is still rank-order logit, with each level in the defined rating scale representing a different class of response.

From an empirical standpoint, these latter methods offer some significant advantages over the conventional contingent valuation method. Respondents are generally more comfortable providing qualitative rankings or ratings of attribute bundles which include prices, rather than dollar valuations of the same bundles without prices. In treating price as simply another attribute, the conjoint approach minimizes many of the biases that can arise in open-ended contingent-valuation studies when respondents are presented with the unfamiliar, and often unrealistic, task of putting prices on nonmarket goods.

Survey Design

During the drafting of the survey questionnaire, focus interviews with various hunters were conducted (1) to identify the major attributes of hunting trips that influence trip preferences; (2) to discern how many hypothetical trips respondents were willing to rank or rate, and how complex those trip descriptions should be; (3) and to compare the practicality of different rating and ranking schemes. The final version of the questionnaire asked respondents to rate hypothetical hunting trips "on a scale of 1 to 10 (1 = completely unsatisfactory trip; 10 = ideal trip)."

Trips were described by the following attributes, and four plausible levels were chosen for each attribute. Travel time (0.5, 1, 2, or 4 hours each way) was included to obtain valuations of travel time;[1] trips requiring longer travel were expected to receive lower ratings. Since some respondents have censored labor-leisure margins while others do not, the vignettes were worded without overt reference to either margin. Since no particular margin was specified, an intramarginal valuation of travel time is obtained.

Trip cost per day ($10, $25, $50, or $100) was included to provide a numeraire for the valuation of other attributes. In theory, it would have been preferable to use a hypothetical site access fee rather than an overall trip cost since respondents might associate more costly trips with omitted trip attributes such as fancier restaurant meals during the trip.[2] However, hunters involved in the focus interviews and survey pretest confirmed that most deer hunters do not pay for access to private land for deer hunting; furthermore, some of the focus interviews revealed particular hunter sensitivity to the issue of access fees and concern about increased posting of private land to control or prohibit hunting. The total-trip-cost attribute was therefore chosen as more realistic and less likely to elicit response bias than the site-access attribute.

Focus-group participants indicated that the type of hunting party (hunt alone, with casual acquaintances, with close friends, or with family) was very important. This reflects a sense of hunting as a sharing of heritage as well as a concern for hunting safety. Hunting trips with close friends or family members were expected to receive higher ratings than hunting alone or with casual acquaintances.

Site congestion (none, slight, moderate, heavy) was expected to reduce trip ratings. Formal quantification of congestion levels (i.e., specified numbers of hunters per thousand acres) would have been useful but proved impractical since respondents were unfamiliar with such density measures. However, focus-group participants did consider site congestion to be a very important attribute, so the heuristic descriptions were included.

The probability of bagging a deer (less than 5%, 5%, 10%, or 20%) was expected to be positively correlated with trip ratings. Both prior research and focus-group responses indicated that this range of probabilities was realistic.

While focus interviews did not indicate that the annual license fee was a particularly important attribute of individual trips, the Delaware Division of Fish and Wildlife was interested in gauging hunter antipathy to increasing license fees; therefore, an annual-license-fee attribute (for Delaware residents: $15, $20, $25, or $30; for nonresidents: $45, $50, $60, or $80) was included in the design. (The actual license fees, not including stamps, were $13.50 for Delaware residents and $45.00 for nonresidents.) Higher fees were expected to reduce trip ratings. The typical deer-hunter respondent actually spent four days hunting deer. Protest would be indicated where a dollar increase in per-trip license costs reduced trip ratings more than the equivalent dollar increase in other trip expenditures. Since the conjoint-question design used strictly orthogonal arrays of attributes, the vignette ratings were expected to be quite robust to the inclusion of an irrelevant attribute.

Other trip attributes, such as wildlife contacts, weather, and type of deer bagged (buck, doe, or fawn), were tested in various pretest versions of the survey. Neither the focus groups' participants nor the Division of Fish and Wildlife considered these attributes sufficiently important to merit inclusion in the final version of the survey.

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[1] Since the vignettes did not specify that the hunting site was in Delaware, a four-hour travel time was quite plausible for both nonresidents hunting in Delaware and Delaware residents hunting out of slate.

[2] This would reduce the variance of a hunter's ratings vis-a-vis trip cost, thus reducing the trip-cost coeflicient in the regression analysis and inflating valuation estimates for other amenities.

Representing all possible permutations of these six attributes requires 4^6, or 4,096 different attribute bundles or vignettes; however, assuming convexity of indifference curves and transitivity of preferences, many of these permutations are logically redundant. The most parsimonious set necessary for evaluating "main effects" (i.e., obtaining marginal valuations of each level of each attribute without considering interactions between attributes) was derived from a Latin square design (Addelman). This parsimonious set included 25 trip vignettes, with the six attributes arrayed orthogonally.

Focus-group participants were more comfortable using a 10-point rating scale than a 100-point rating scale. They also confirmed that many respondents would likely refuse to rank or rate all twenty-five different trip descriptions on either type of scale in a mail-back survey. Therefore, an eight-level pseudoattribute was included in the design to split the parsimonious set of vignettes into eight" blocks" (see Green 1984) so that individual respondents would only have to rate the trips within a single block. The inclusion of the block pseudoattribute increased the minimum parsimonious set to thirty-two cards, with four cards in each block. The cards in each of the eight blocks include all levels of all attributes. Each block was included in a separate version of the survey, and each respondent was asked to rate the appeal of each of the four trips described in the block. Figure 2 shows an example of one block of four cards.

During the summer of 1989 a six-page mail-back survey, including the conjoint questions, was administered to 3,351 of the 25,592 hunters who purchased Delaware hunting licenses for the 1988-89 hunting season.[3] Since the survey questionnaire was quite lengthy, the response rate was boosted by offering respondents free subscriptions to *Delaware Conservationist* magazine (published by the Delaware Department of Natural Resources and Environmental Control, which funded the survey effort) and by sending a sequence of follow-up postcards and duplicate questionnaires to encourage nonrespondents to respond. A 42% response rate was ultimately achieved, and the survey yielded 1,384 usable responses. Of these, 841 respondents hunted deer at least one day during Delaware's 1988-89 deer-hunting season.

Figure 2. Sample Conjoint Questions, 1989 Delaware Hunter Survey (One of Eight Blocks)

Now consider a few combinations of these trip features. Four alternative deer-hunting trips are outlined below. Please indicate how you would rank *each* of these trips on a *scale of I to 10* (I - completely unsatisfactory trip; 10 - ideal trip).

Trip A	Trip B
Travel Time: 2 hours each way	Travel Time: 4 hours each way
Total Cost/Day: $100	Total Cost/Day: $10
Type of Group: casual acquaintances	Type of Group: family
Site Congestion: slight	Site Congestion: none
State License Fee: $25	State License Fee: $20
Chance of Bagging a Deer: 10 percent	Chance of Bagging a Deer: 5 percent
RATING: ______	RATING: ______

Trip C	Trip D
Travel Time: '/2 hour each way	Travel Time: i hour each way
Total Cost/Day: $50	Total Cost/Day: $25
Type of Group: close friends	Type of Group: hunt alone
Site Congestion: heavy	Site Congestion: moderate
State License Fee: $15	State License Fee: $30
Chance of Bagging a Deer: < 5 percent	Chance of Bagging a Deer: 20 percent
RATING: ______	RATING: ______

Analytical Results

Of the 554 respondents answering the conjoint question, only 2 provided unusable responses. Each of the other 552 respondents provided four trip ratings in the conjoint question, yielding 2,208 total rating observations. Using Hatred's rank-order logit procedure, these ratings were regressed against travel time *(TRAVTIME),* trip cost per day *(TRIP-COST),* the license fee *(LICNSFEE),* three dummy variables *(FAMILY, FRIENDS, ACQUAINT)* representing the four group types (hunting alone is accounted for in the intercept term), three dummy variables *(CONGEST},* *CONGEST!,* and *CONGEST!)* representing slight, moderate, and severe site congestion, respectively (no congestion is accounted for in the intercept term), and the percent probability of bagging a deer *(PROBDEER)* (the "< 5%" level was coded as zero). Seven dummy variables *(BLOCKA* through *BLOCKG)* were included to account for differences in average ratings of the eight blocks of cards not attributable to differences in attribute levels (the last block is accounted for in the intercept term). The logit procedure estimates a separate constant (denoted in the estimation results in Table 1 as *ALPHAl* through *ALPHA9)* to account for each rating interval. In effect, this procedure collapses the data to fit a unit indifference function, which is valid if the utility function is assumed to be

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[1] A detailed discussion **of this** survey and the summary statistics from it is included in Eduljee and Mackenzie.

Table 1. Logistic Regression of Trip Ratings on Attribute Levels, Conjoint Analysis, 1988-89 Delaware Hunter Survey

Variable	Coefficient (M	Standard Error	Chi-square	Marginal Valuation (*bj* /PTK/PCOST)
ALPHA I	2.2459	0.1798	155.99	
ALPHA2	1.8551	0.1789	107.55	
ALPHAS	1.5245	0.1781	73.29	
ALPHA4	1.2490	0.1774	49.56	
ALPHAS	0.5638	0.1761	10.25	
ALPHA6	0.3107	0.1758	3.12	
ALPHA?	-0.0806	0.1756	0.21	
ALPHAS	-0.8068	0.1766	20.88	
ALPHA9	-1.1247	0.1776	40.09	
TRAVTIME	-0.2549	0.0236	116.28	-$24.72
TRIPCOST	-0.0103	0.0009	122.06	-$1.00
UCNSFEE	-0.0083	0.0020	17.8	-$0.81
FAMILY	0.1407	0.0892	2.49	$13.65
FRIENDS	0.4360	0.0890	23.99	$42.28
ACQUAINT	-0.3654	0.0883	17.12	-$35.44
CONGESTl	-0.1806	0.0880	4.21	-$17.52
CONGEST?	-0.5726	0.0880	42.39	-$55.54
CONGESTS	-1.5392	0.0919	280.65	-$149.29
PROBDEER	0.0705	0.0044	257.53	$6.84
BLOCKA	-0.1308	0.1210	1.17	
BLOCKS	0.1800	0.1796	2.22	
BLOCKC	0.0345	0.1256	0.08	
BLOCKD	0.3112	0.1263	6.07	
BLOCKE	0.2374	0.1300	3.34	
BLOCKF	0.1886	0.1268	2.21	
BLOCKG				

homothetic;[4] i.e., the marginal rate of substitution between attributes remains constant when attribute levels are varied proportionately.

The logit procedure therefore fitted the trip ratings to a logistic transform of a linear combination of right-hand-side variables:

$$RATING = 1/[1 \text{ -I- } \mathrm{exp}''^{(ZB)}], \tag{4}$$

where:

$$\begin{aligned} ZB = {} & a_1 + a_2 + \ldots + a_9 \\ & + btTRAVTIME + b_2TRIPCOST + \\ & biUCNSFEE + b_4FAMILY + \\ & bsFRIENDS + b\text{^}CQUAJNT + \\ & b_7CONGESTl + b_{\%}CONGEST2 + \\ & b_9CONGEST3 + b_{lo}PROBDEER + \\ & CiBLOCKA + c_2BLOCKB + \ldots \\ & + {}_{C}BLOCKG. \end{aligned}$$

Each value of the linear combination *ZB* yields a unique predicted rating. Any two attributes in *ZB* can be varied so as to leave the value *of ZB,* and hence the predicted rating, unchanged. Marginal rates of substitution between any attributes X_t and *Xj* can therefore be calculated as the ratio of their corresponding coefficients, *b-Jbj.*

Marginal valuations of various trip attributes are likewise obtained by dividing each attribute coefficient by the coefficient on *TRIPCOST.* For example, the marginal valuation of travel time (i.e., the extra trip cost the typical respondent is just willing to incur in order to reduce travel time, leaving the predicted rating, which represents utility, unchanged) equals bi/b_2, the coefficient on *TRAVTIME* divided by the coefficient on *TRIPCOST.* Since *TRAVTIME* is measured in hours, $b_{\{}$ represents logistically transformed ratings points per hour, and since *TRIPCOST* is in dollars, b_2 represents logistically transformed ratings points per dollar. Therefore, the ratio b_l/b_2 expresses the time valuation in dollars per hour.

The estimation results in Table 1 indicate that all of the included attributes influence trip ratings significantly and as hypothesized. The last column in Table 1 presents the ratios of the coefficient on each attribute variable divided by the coefficient on *TRIPCOST.* Since the *TRIPCOST* coefficient is so highly significant, all of the marginal-valuation estimates except that on the *FAMILY* dummy are clearly significant.

The estimated *TRAVTIMEITRIPCOST* coeffi-

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[4] This assumption of homotheticity can be tested via a polytomous logil approach in which separate sets of attribute coefficients are estimated for each raiing level. If utility is homothetic, the coefficients on the different attributes will maintain a constant proportionality vis-a-vis one another across coefficient sets.

cient ratio indicates a marginal valuation of $24.72 for a one-hour reduction in travel time. In contrast, the average hourly wage equivalent for the sample is about $14, as implied by the sample average annual income of $28,100. The very high chi-square statistics for the *TRAVTIME* and *TRIPCOST* coefficients indicate that this difference is significant. The $24.72 per hour valuation of travel time is far more in line with observed daily hunting expenditures, which commonly exceed $100 per day, and more plausibly reflects the cost of time displaced at the travel-time/time-on-site margin.

The implied marginal valuation of a 1% increase in the probability of bagging a deer is $6.84 (the parameter on *PROBDEER* divided by the parameter on *TRIPCOST).* The statistical value of a deer to many hunters, each of whom has a fairly low probability of bagging a deer, is thus estimated at $684. However, this does not necessarily imply that a typical hunter would be willing to pay $684 for the certainty of bagging a deer. This figure is more than twice as large as a valuation estimate derived from a household production analysis of deer hunting based on a previous survey of Delaware hunters (Mackenzie).

The coefficient on the license-fee variable is surprisingly large vis-a-vis the coefficient on the trip-expenditure variable. The implicit marginal rate of substitution between dollar expenditures per trip and license expenditures per season is 0.81. This result implies that hunters clearly prefer increases in other trip costs to equivalent increases in per-trip license costs. Since respondent deer hunters averaged about four deer-hunting days per season, indifference between the per-trip expenditures for the hunting license versus per-trip travel costs would imply a marginal rate of substitution near 0.25.

There are two possible reasons for this result. First, it probably reflects protest against increased license fees. Second, additional trip expenditures (for meals in fancy restaurants, say) may provide extra utility that additional license fees do not. If respondents do associate higher trip costs with positive trip attributes not accounted for in the conjoint model, this would reduce the variation in ratings, bias the coefficient on *TRIPCOST* down ward, and thus bias the estimated valuations of all trip attributes downward.

The results show clear preferences for hunting with close friends (ranked first) or family members (ranked second, just above hunting alone) versus hunting with casual acquaintances. This probably reflects both concern for hunting safety and a sense of hunting as a sharing of heritage.

Congestion costs are clearly significant in this model (although they were not quantifiable) and potentially very large. The estimated implicit cost of "moderate' * congestion vis-a-vis "slight" congestion is $55.54 per day; the estimated implicit cost of "severe" congestion vis-a-vis "moderate" congestion is $149.29 per day.

The generally insignificant coefficients on the *BLOCK* dummies suggest that the eight blocks each contain reasonably equivalent sets of vignettes. Since each block presented respondents with all levels of all attributes in different combinations, this result also provides weak evidence that possible joint effects of attribute combinations on ratings not accounted for in this model are not significant.

Alternative Specifications

Various modifications of this model were estimated to test the robustness of these results. Although the set of vignettes used in the survey was designed with zero covariance between attributes, a hypothesized interaction between site congestion and likelihood of hunting success was tested. The interaction variable was constructed by multiplying the probability of bagging a deer by a four-level congestion index (0 = none, 1 = slight, 2 = moderate, 3 = severe) and was included in the model to test for jointness in the response data. Not surprisingly, this joint-effect variable proved to be insignificant.

The linear combination of attributes such as travel time and trip expenditures results in constant marginal valuations of attributes. Several alternative specifications were estimated to test the stability of the marginal valuation of travel time across the range of trip times offered and the valuation of marginal probabilities of hunting success across the range of likelihoods offered.

First, the variable *TRAVTIME* was replaced with three dummy variables representing one-hour, two-hour, and four-hour trips (each way), with the intercept term incorporating a half-hour trip time. Coefficients on these dummy variables are used to estimate implicit total valuations of travel time over different amounts of travel time. Figure 3 plots these valuations against travel hours; chi-square values are appended to each valuation estimate. The coefficient on the one-hour travel-time dummy is insignificant.

A quadratic specification with *TRAVTIME* and *TRAVTIME* squared was also estimated, but the coefficient on the squared term was insignificant. Thus, the null hypothesis of a constant marginal valuation of travel time cannot be rejected.

A similar pair of alternative models was estimated in which the variable *PROBDEER* was first replaced with three dummy variables representing

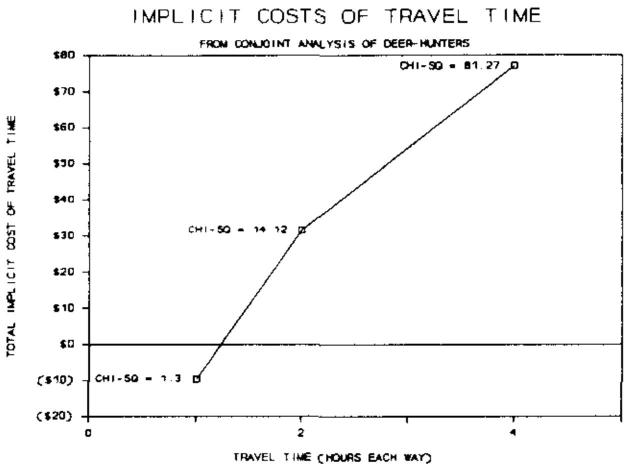

Figure 3. Implicit Costs of Travel Time for Deer Hunters

5%, 10%, and 20% likelihoods of bagging a deer. Again, coefficients on these dummy variables are used to estimate implicit total valuations of the different probabilities of hunting success. All three coefficients on these dummy variables are significant. Figure 4 plots these valuations against the probabilities.

A quadratic specification with *PROBDEER* and *PROBDEER* squared yielded an insignificant coefficient for *PROBDEER* squared. The null hypothesis that the marginal valuation of hunting success is constant, at least over plausible probabilities of success ranging from less than 5% through 20%, cannot be rejected. The $684 statistical value of a deer derived above is not contradicted by this result.

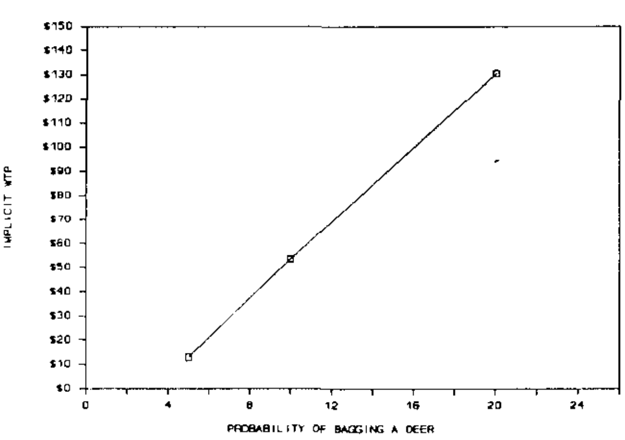

Figure 4. Implicit Valuations of Probabilities of Success

Summary and Conclusions

The results of this analysis suggest that conventional valuations of recreational travel time at the hourly wage equivalent, or at some fraction thereof, may significantly understate the true opportunity costs of travel time. The valuation of recreational travel time obtained here appears to reflect the cost of foregone hunting time, which deer hunters apparently value at almost twice the hourly wage rate of foregone work. Conventional travel-cost analyses, which account for costs of travel time based on wage-rate equivalents, may therefore misstate true recreational amenity values.

Deer hunting is shown to be a composite recreational good embodying multiple attributes that may be difficult to evaluate via other methods (e.g., companionship and escape from congestion as well as hunting success). Since the typical deer hunter does not bag a deer in a given season, the value of a deer is derived from valuations of plausible small increments in the likelihood of hunting success.

The conjoint approach represents a useful methodological complement to conventional CVM and hedonic travel-cost methods of evaluating recreational and other environmental amenities. It is utility-theoretic in a quite literal way. Viewed as an extension of referendum-based CVM, it offers excellent informational efficiency via a question format that respondents find plausible and easy to understand. Compared with open-ended CVM, the conjoint method minimizes protest responses by subsuming price within vignettes.

Although vignette ratings seem to lack precision, they are intuitively appealing to respondents and they embody all of the information obtained from preference rankings plus at least some information about relative intensities of preferences. Regressing ratings against attribute levels via rank-order logit instead of OLS avoids the fallacy of attributing cardinal significance to the ratings while still permitting easy calculation of marginal rates of substitution between attributes.

References

Addelman, Sidney. "Orthogonal Main-Effect Plans for Asymmetrical Factorial Experiments." *Technometrics* 4, no. 1 (1962):21-46.

Bishop, Richard C., and Thomas A, Heberlein. "Measuring Values of Extra-Market Goods: Are Indirect Measures Biased?" *American Journal of Agricultural Economics* 61, no. 5 (1979}:926-30.

Bishop, Richard C., Thomas A. Heberlein, and Mary Jo Kealy.

"Contingent Valuation of Environment Assets: Comparison with a Simulated Market." *Natural Resources Journal* 23 (1983):619-33.

Bockstael, Nancy E., and Kenneth E. McConnell. "Theory and Estimation of the Household Production Function for Wildlife Recreation." *Journal of Environmental Economics and Management* 8 (1981):199-214.

Bockstael, Nancy E., Ivar E. Strand, and Michael Hanemann. "Time and the Recreational Demand Model." *American Journal of Agricultural Economics* 69, no. 2 (1987):293-302.

Boyle, Kevin J., and Richard C. Bishop. "Welfare Measurements Using Contingent Valuation: A Comparison of Techniques." *American Journal of Agricultural Economics* 70, no. t (1988}:20-28.

Brown, Gardner. "Valuing Oregon Salmon by Using a Multimarket, Hedonic Travel Cost Method." In *Sport Fishing: A Comparison of Three Indirect Methods for Estimating Benefits,* ed. D. Hueth, E. J. Strong, and R. J. Fight. USDA Forest Service Research Paper PNW-RP-395. Pacific Northwest Research Station, Portland, OR, 1988.

Brown, Gardner, and Robert Mendelsohn. "The Hedonic Travel Cost Method." *Review of Economics and Statistics* 66, no. 3(1984):427-33.

Cameron, Trudy Ann. "A New Paradigm for Valuing Nonmarket Goods Using Referendum Data." *Journal of Environmental Economics and Management* 15 (1988): 355-79.

Cameron, Trudy Ann, and Michelle D. James. "Efficient Estimation Methods for 'Closed-Ended' Contingent Valuation Surveys." *Review of Economics and Statistics* 69, no. 2 (1987):269-76.

Cesario, Frank J. "Value of Time in Recreation Benefit Studies." *Land Economics 52* (1976):32-41.

Eduljee, Benaifer, and John Mackenzie. "The 1989 Delaware Hunter Survey." University of Delaware, Agricultural Experiment Station Bulletin. Newark, DE. Forthcoming.

Freeman, Myrick A. "The Benefits of Environmental Improvement: Theory and Practice." Resources for the Future. Baltimore: Johns Hopkins University Press, 1979.

Gineo, Wayne. "A Conjoint/Logit Analysis of Nursery Stock Purchases." *Northeastern Journal of Agricultural and Resource Economics* 19 (April 1990):49-58.

Goodman, Alien C. "Identifying Willingness-To-Pay for Heterogeneous Goods with Factorial Survey Methods." *Journal of Environmental Economics and Management* 16 (1989):58-79.

Green, Paul E. "On the Design of Choice Experiments Involving Multifactor Alternatives." *Journal of Consumer Research* 10 (1974):61-68.

____. "Hybrid Models for Conjoint Analysis: An Expository Review." *Journal of Marketing Research* 21 (1984): 155-69.

Green, Paul E., J. Douglas Carroll, and Stephen M. Goldberg. "A General Approach to Product Design Optimization Via Conjoint Analysis." *Journal of Marketing* 45 (1981): 17-37.

Green, Paul E., and Vithala R. Rao. "Conjoint Measurement for Quantifying Judgmental Data." *Journal of Marketing Research* 8 (1971):355-63.

Green, Paul E., and V. Srinivasan. "Conjoint Analysis in Consumer Research: Issues and Outlook." *Journal of Consumer Research 5* (1978):103-23.

Gum, Russell L., and William E. Martin. "Problems and Solutions in Estimating the Demand for and Value of Rural Outdoor Recreating." *American Journal of Agricultural Economics* 57, no. 4 (1975):558-66.

Hammack, Judd, and M.G. Brown, Jr. *Waterfowl and Wetlands: Toward Bioeconomic Analysis.* Resources for the Future. Baltimore: Johns Hopkins University Press, 1974.

Hanemann, W. Michael. "Welfare Evaluations in Contingent Valuation Experiments with Discrete Responses." *American Journal of Agricultural Economics* 66 (1984): 332-41.

____. "Some Issues in Continuous- and Discrete-Response Contingent Valuation." *Northeastern Journal of Agricultural and Resource Economics* 16, no. 1 (1985):5-13.

Harrell, Frank E., Jr. "The LOGIST Procedure." In *SUGI Manual.* Gary, NC: SAS Institute, 1980.

Luce, R. Duncan, and John W. Tukey. "Simultaneous Conjoint Measurement; A New Type of Fundamental Measurement." *Journal of Mathematical Psychology* 1 (1964): 1-27.

Mackenzie, John. "Toward the Economic Valuation of Hunting and Public Wildlife Management." University of Delaware, Agricultural Experiment Station Bulletin 473. Newark, DE, 1988.

Madansky, Albert. "On Conjoint Analysis and Quantal Choice Models." *Journal of Business* 53, no. 3.2 (1980):S37-S44.

Maler, Karl-Goran. *Environmental Economics.* Resources for the Future. Baltimore: Johns Hopkins University Press, 1974.

McConnell, Kenneth E. "Values of Marine Recreational Fishing—Measurement and Import of Measurement." *American Journal of Agricultural Economics* 61, no. 5 (1979):922-25.

————. "Models for Referendum Data: The Structure of Discrete Choice Models for Contingent Valuation." *Journal of Environmental Economics and Management* 18 (1990):19-34.

McConnell, Kenneth E., and Ivar E. Strand. "Measuring the Cost of Time in Recreation Demand Analysis." *American Journal of Agricultural Economics* 63, no. 1 (1981): 153-56.

McFadden, Daniel. "Conditional Logit Analysis of Qualitative Choice Behavior." In *Frontiers in Econometrics,* ed. P. Zarembka, 105-42. New York: Academic Press, 1974.

Ross, A.D., T.H. Stevens, and P.G. Alien. "Measurement of Recreation Benefits for Urban-oriented Camping." University of Massachusetts, Massachusetts Agricultural Experiment Station, Research Bulletin 667. Amherst, MA, 1981.

Schulze, William D., Ralph C. d'Arge, and David S. Brookshire. "Valuing Environmental Commodities: Some Recent Experiments." *Land Economics* 57, no. 2 (1981): 151-72.

Wilman, Elizabeth A. "The Value of Time in Recreation Benefit Studies." *Journal of Environmental Economics and Management 1* (1980):272-86.