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Combining Revealed and Stated Preference Methods for Valuing Environmental Amenities

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Abstract

A stated preference model and a revealed preference model for recreational site choice are examined and compared. Both models are based on random utility theory and the data are obtained from the same individuals. The stated preference model is based on the respondent's choice from hypothetical choice sets. Attributes in the stated preference model are based on the actual levels of attributes in the revealed preference choice set, and are presented to respondents using a fractional factorial statistical design. The results show that while independently estimated models appear to reflect different underlying preferences, joint estimation of the model parameters, including estimation of the relative scale parameter, provides evidence that the underlying preferences are in fact similar. Furthermore, combining the revealed and stated preference information yields other benefits in estimation.

Combining Revealed and Stated Preference Methods for Valuing Environmental Amenities

Introduction

Methods for valuing environmental amenities have traditionally been categorized as indirect and direct. Indirect methods, like the travel cost model, use actual choices made by consumers to develop models of choice. These constitute revealed preferences over goods, both market and non-market. Direct methods ask consumers what they would be willing to pay or accept for a change in an environmental amenity. Direct methods are examples of stated preference techniques in that individuals do not actually make any behavioral changes, they only state that they would behave in this fashion.

Both methods have advantages and drawbacks. Direct methods are commonly criticized because of the hypothetical nature of the questions and the fact that actual behavior is not observed (Cummings et al [9], Mitchell and Carson [23]). However, direct methods currently provide the only viable alternative for measuring non-use values and they are commonly used to elicit values in cases in which the environmental quality change involves a large number of attribute changes. Indirect methods avoid the criticism of being based on hypothetical behavior, but, the models of behavior developed constitute a maintained hypothesis about the structure of preferences which may or may not be testable. Indirect methods may also suffer on the grounds that the new situation (after the environmental quality change) may be outside the current set of experiences (or outside the data range) and thus simulation of the new situation would involve extrapolation outside the range used to estimate the model. Finally, indirect methods may suffer from colinearity among attributes. Colinearity precludes the isolation of factors affecting choice. This isolation is often required in economic welfare analysis. For example, water quality attributes (BOD, turbidity, etc) may be correlated but the economic valuation may only be interested in valuing an improvement in one of the attributes. The separation of these attributes is necessary for an accurate representation of the benefits and for policy analysis.

In this paper we examine a stated preference approach which parallels a revealed preference model for recreation demand site choice. This stated preference model differs significantly from contingent valuation in that it presents the respondent with sets of choices of bundles characterized by attributes of recreation sites. The attribute levels chosen for the stated preference technique are based on those used for the revealed preference analysis. Thus, the two techniques are using similar factors to explain choice; revealed choice and stated choice. However, the stated preference method employs a statistical design which eliminates colinearity among the attributes. The attribute levels presented to the respondent are chosen using a fractional factorial main effects design (Louviere and Hensher [13], [14], Louviere and Woodworth [15], Louviere [16], [17], [18], Batsell and Louviere [2]). While this model has been applied to the analysis of demand for market goods (eg. Bunch et al. [6], Louviere and Hensher [14], Louviere and Woodworth [15], Louviere [18]), to our knowledge it has not been widely used in the nonmarket valuation field.

Both the revealed preference and stated preference models are discrete choice models. In the revealed preference case the individuals choose one recreation site from all sites available to them. The model explains the choice of site as a function of travel distance and quality attributes of the sites. The stated preference model explains the choice of one alternative over the other as a function of the attributes which include travel distance and the same quality attributes. Both models reflect the same tradeoffs and both can be considered applications of random utility theory.

Since the two approaches reflect the same process of choosing recreation sites based on attributes, it is possible to combine the analyses. The advantages of jointly estimating the model are the following. First, the stated preference information reduces colinearity that may be present in the revealed preference data set. Therefore, attribute effects that were previously unidentified or weakly identified due to colinearity can now be more clearly identified. Secondly, in cases where the actual data do not encompass the range of the proposed changes, stated preference experiments can be used to include the range of the proposed changes within the data series.

The stated and revealed preference models are estimated using multinomial logit techniques. It is widely recognized that when operating in a random utility context, the scale parameter in the error term is arbitrarily assumed to be unity. This assumption has no effect on the utility levels within each of the separate revealed preference and stated preference models. However, the scale parameters could be quite different between the two models, reflecting the respective levels of variation in the two different data sets (Ben-Akiva and Lerman [5], 104-106). In the analysis which follows we show that there is a significant correlation in the underlying preferences as described by the predicted proportions of visits to each site. The difference between the two models appears to lie in the scale factor. Therefore, we estimate the joint model and simultaneously estimate the relative scale factor for the stated preference data which results in the highest likelihood value. With two separate data series it is possible to estimate the scale factor for one of the series, jointly with the other parameters, as the value resulting in the highest likelihood (Ben-Akiva and Morikawa [4], Swait and Louviere [24]).

Each technique produces results that are based on random utility theory, hence, either can be used for welfare analysis of environmental quality changes. Similarly, the joint model can be used for welfare calculations. In the application presented below, we applied stated and revealed preference models to the evaluation of alternative flow scenarios for the Highwood and Little Bow rivers in southwestern Alberta. These flow scenarios were developed to better satisfy instream flow needs (IFN) for recreation, fisheries, wildlife and stream ecology, as required by the Water Management Policy for the South Saskatchewan River Basin. We employ the welfare economic propositions derived from the random utility model to estimate the economic value of the improvements in environmental quality associated with the flow scenarios. Because the stated preference, revealed preference and joint models are all based on random utility models, we can compare the results of the three approaches.

The rest of the paper proceeds as follows. The next section contains a description of the stated preference approach, followed by a brief review of the revealed preference approach. The data and empirical results are then presented. The fact that the stated preference model can be used for welfare calculation suggests that it can be used for non-use value measurement as well as the use value application we present here. We discuss this type of extension at the end of the paper.

Stated Preference Model

Stated preference models are common in the marketing and applied decision research literature (Louviere, etc). These techniques are often referred to as "experimental or stated choice analysis" or "conjoint techniques". A case for their use in market research and economic analysis has been presented by McFadden [20]. Stated preference approaches involve asking respondents to rank or judge attributes or products or asking respondents to choose from hypothetical choice sets ([6]; [16]; [17]; [18]). The approach we use is to develop hypothetical choice sets in which the choices are described by bundles of attribute values associated with water based recreation.

In order to design the choice sets, a set of attributes affecting the choice of recreational sites was developed to reflect actual characteristics of water-based recreational resources in the study area. These 13 attributes and the levels chosen for our analysis are listed in Table 1. In our study area, recreational fishing is a significant form of recreation and thus the attribute list contains several variables relating to fishing activity and success. The list also includes travel distance, and other features relating to the scenic value of the sites. Also, some attributes are alternative specific, such as the Water Feature. This attribute depends on a higher level of attribute, running or standing water. Note that the attribute levels varied in the choice sets are discrete even though in some cases they reflect underlying continuous variables. Discrete attribute levels are a consequence of the statistical design process used to create the choice sets.

Research Approach

The set of attributes and levels displayed in Table 1 can be viewed as setting the space to be spanned in the choice experiment. If we treat each attribute as discrete, as in Table 1, there are $2^5 \times 4^5$ possible Standing Water alternatives, and an additional $2^4 \times 4^5$ possible Running Water alternatives. The problem of choice set construction, therefore, can be viewed as sampling from the universe of possible pairs of Standing and Running Water alternatives. Methods of design construction for such problems have been considered by Louviere and Hensher [14], Louviere and Woodworth ([15]), Louviere ([16]; [17]) Batsell and Louviere [2] and Bunch, Louviere and Anderson [7] under the assumption that the choice process can be described by McFadden's [22] "Mother" logit model or its special cases, such as conditional logit ([21]). Design strategies described in these sources are consistent with various subset forms of the more general "Mother" logit form, and produce consistent estimates of the parameters of these models. In fact, McFadden [20] has referred to these design strategies as "powerful" methods for estimating and testing violations of the IIA property of simple, conditional logit models.

In the present case, we wished to insure that we could test for violations of the IIA property of simple, conditional logit. Towards this end, we designed the choices sets by treating each of the attributes of Standing and Running Water as separate attributes with the numbers of levels as given in Table 1. Thus, the design problem consists of sampling from the entire $(2^5 \times 4^5) \times (2^4 \times 4^5)$ factorial in such a way that we can estimate all the parameters of interest with a reasonable degree of statistical efficiency. Recently, Bunch, Louviere and Anderson [7] have demonstrated that an orthogonal main effects design drawn from the larger factorial permits estimation of all alternative-specific attribute effects, as well as violations of IIA. Additionally, their Monte Carlo work indicates that this design, while not optimally efficient, is relatively efficient. Optimal efficiency requires one to know the true choice probabilities prior to design; hence, is currently not an attainable objective in choice experiments of this kind. The final design consisted of 64 choice sets, which are pairs of competing attribute bundles describing Standing and Running Water options.

It is unrealistic to assume that individuals can or will respond to all 64 choice sets in an interview setting, especially a mail survey setting of the type we employed in this research. Consequently, we blocked the experiment into four sets of 16 choice sets by using an additional four-level column as a factor in the design. Blocking in this manner insures that each block of choice sets is approximately statistically equivalent. The 16 choice sets in each block were placed into a survey format, which was described as a "Recreation Game". As part of the survey materials, each respondent received a set of instructions for completing the survey and the choice task, a glossary describing the meaning of each of the attributes and levels in plain English and a telephone contact number for additional assistance. The respondent's task was to choose between either a Standing or Running Water alternative described in each choice set or to decide to choose not to engage in water based recreation for their next one-day or overnight outing.

The latter, or "null" choice, is not only convenient for estimating demand for the water-based recreation activities of swimming, fishing or boating, but it also serves an important role in the design. In particular, conditional logit models are estimated from differences in attribute levels relative to some reference alternative. The design strategy employed generates orthogonal arrays of absolute attribute levels, not differences in levels. The addition of a constant reference option to all choice sets insure that the differences are with respect to this constant, which retains estimation orthogonality. It is the latter property which provides for relative parameter efficiency. Thus, each choice set constitutes a choice among three options, and the third or "null" option is used to set the origin of the utility scale for convenience.

Data

The data used for the stated preference analysis were obtained from a survey of individuals in the study region. Initial contacts were made by a random sample telephone survey (see Alberta Environment [1] for details on the survey), The telephone survey was designed to generate a set of 800 respondents who were willing to complete the choice experiment. This "recreation game" contained the 16 sets of choices described above. 413 respondents provided complete answers to the choice experiment.

Analysis

The response to the choice between 3 constructed recreation choice alternatives can be modeled in a Random Utility framework. The overall utility can be expressed as the sum of a systematic component, which is expressed as a function of the attributes presented, and a random component. More formally, this can be expressed as:

$$U_{in} = v_{in} + e_{in} \tag{1}$$

where U_{in} is person n's utility of choosing site (alternative) i, v_{in} is the systematic component of utility and e_{in} is a random element. Site (alternative) i is chosen over site j if $U_{in} > U_{jn}$. The probability of individual n choosing site i is;

$$\pi_n(i) = Pr\{v_{in} + e_{in} \geq v_{jn} + e_{jn}; \forall j \varepsilon C_n\} \tag{2}$$

where C_n is the choice set for individual n. v_{in} is a conditional indirect utility function and we assume it has a linear form;

$$v_{in} = \beta_1 + \beta_2 x_{in2} + \beta_3 x_{in3}, \ldots + \beta_k x_{ink} + \alpha(Y - P_i) \tag{3}$$

where x_{ink} are attributes of the site (alternative), Y is income and P_i is the price (or travel cost) of accessing the site. Assuming that the error terms are Gumbel distributed with scale parameter μ, the probability of choosing site i is

$$\pi_n(i) = \frac{\exp^{\mu V_{in}}}{\Sigma_{j\varepsilon C_n} \exp^{\mu V_{jn}}} \tag{4}$$

Note that the scale factor μ remains in this expression, and is typically assumed to equal 1. However, since we have two separate data sets, it is possible to jointly estimate the relative scale factor (or ratio of the two scale parameters) for one set along with the model parameters for the joint data. A more detailed discussion of this procedure is presented below.

Formulated in such a manner, the stated preference model is described exactly like a revealed preference travel cost model. Welfare measures from that model can be developed using the theory applied to revealed preference discrete choice models (Hanemann [12]). A measure commonly used to examine the impact of a quality change is

$$CV = -\frac{1}{\alpha}\left\{ \ln\left(\sum_{i\varepsilon C_n} \exp(v_{n0})\right) - \ln\left(\sum_{i\varepsilon C_n} \exp(v_{n1})\right)\right\} \qquad (5)$$

where α is interpreted as the marginal utility of income, v_{n0} is the initial state (or quality level) and v_{n1} is the level of utility in the subsequent state. In the empirical analysis presented below, the parameters of the discrete choice model are estimated using the stated preference data. These parameters are then applied to determine the choice probabilities for each site in the actual area under investigation. The attribute levels associated with the various flow scenarios are used to generate measures of welfare.

Results

The results of the logit analysis of the stated preference data are presented in Table 2. The model has a very good fit (McFadden's $\rho^2 = .76$), and the parameters have signs consistent with our expectations. All parameters except distance are estimated as interactions with the water feature (standing or running water). Larger fish, increased catch rates, good water quality, and the availability of swimming and beaches are factors which positively affect utility. Mountains and foothills are preferred to flat prairie and rolling prairie. More fish species are preferred to fewer with the package of rainbow trout, mountain whitefish and brown trout providing the highest utility[1]. Fully serviced campsites are preferred on both standing and running water sites. Distance is a negative factor as expected. Note that there are differences between the running and standing water coefficients. An increase in fish catch or size, for example, would produce a larger increase in utility at running water sites than at standing water sites.

The parameters from the stated preference model were estimated from the respondent's choice from a set of three hypothetical alternatives. However, the attributes can be associated with actual recreation sites and the model can be used to determine the probabilities of choosing each site. A choice set, which reflects the set of sites from which the consumer can choose, must be defined. For this study, the choice set was defined as 24 recreational sites in the region of the project. These 24 sites were chosen on the basis of their role as substitutes for each other and their location both within the study region and approximately 2 hours driving time from the population centers in the region.

To evaluate the current conditions, attributes for the 24 sites were combined with the parameters from the model to produce a distribution of trips predicted by the stated preference model. This set of sites represents the major recreational reservoirs and rivers in the region. This combination of actual attributes and stated preference model parameters was also used to create the utilities necessary for the welfare calculation. To evaluate the effects of changing river flows to better satisfy instream flow needs, the attributes were changed to reflect the hydrological and biological conditions associated with the new flow regimes, based on information provided by various environmental consultants. In general, the modified flow regimes are expected to affect fish catch rates and species composition at sites along the Highwood and Little Bow rivers. Also included in the analysis is the construction of an on-stream reservoir that would include opportunities for fishing, boating and day-use recreation, and improve an existing lake (Clear Lake) which is currently not fishable.

The welfare measures were calculated from the expression in equation 5. Per trip welfare measures were calculated using the absolute value of the coefficient of travel cost as the marginal utility of income. The resulting welfare measures are presented for each residence zone. Unfortunately, no socioeconomic data on respondents except residence zone were available for the analysis. Therefore the welfare results were identical for respondents from a residence zone but varied across residence zones. The welfare measures are presented in Table 5. Welfare measures are presented both without including time values (based on a travel cost of $0.27 per kilometer) and with time values (assuming a value of time of $10 per hour). These two cases provide a measure of the sensitivity of the results to the value of time. The per-trip welfare measures vary by residence zone from a maximum of $8.06 for residents of zone 21 (travel cost only) to a minimum of $4.33 (zone 10 residents). These variations are the result of distance to the sites.

Revealed Preference Analysis

Information on the actual choices of recreation sites was collected from the same sample of individuals who provided responses to the stated preference survey. Therefore, a comparison between the stated preferences and the revealed preferences for the same set of individuals is possible.

Data

The individual trip response variables were obtained from the recreation telephone survey conducted for Alberta Environment. Within the telephone survey individuals were asked to report the destination of the recreation trips they took during the month of August, 1991. These trip destinations were coded to correspond with the sites in the study area. The sample produced information on 730 usable trips which were included in the statistical model.

Attribute levels for the various sites were the actual levels (for each site) of the attributes used in the stated preference model. This information was obtained from various consultant reports as well as expert judgement by staff at Alberta Environment and Alberta Forestry, Lands and Wildlife. Travel distances were calculated from each residence zone to each recreation site.

A multinomial-logit discrete-choice model of site choice was specified and estimated. Travel cost (distance) and other site attributes were used to explain site choices. The quality factors could not all be entered into the statistical analysis. Some factors reflected similar information for the sites and therefore could not be separated in the statistical analysis. The resulting model contains a subset of the parameters estimated in the stated preference model.

Results

The model was estimated using a variety of combinations of attributes and the most complete model (presented in Table 2) was used to analyze the welfare impacts of the changes introduced by the project. As in the stated preference model, most parameters were estimated with separate coefficients for the attribute on running water and on standing water. The revealed preference model has a McFadden's $\rho^2 = .28$, which is considerably lower than the goodness of fit measure for the stated preference model. This probably results from the fact that there are many more factors which influence site choice in the real world, while in the stated preference model the choices are somewhat simplified and focused.

The statistical model indicates that distance, water quality, fishing success, presence of swimming areas, the availability of boating, and the presence of beaches are significant factors influencing site choice. The sign on distance is negative indicating that sites are less attractive if they are further away from the respondent's home. The signs on fishing success and boating variables are positive indicating that the availability of these attributes (or higher levels of success) positively influences choice. Water quality coefficients are negative because the variable is 1 for poor sites and 0 for good sites. The site specific shift constants are included to account for factors not collected in the quality attribute database that influence choice of these particular sites. These four site specific constants are chosen because they represent some of the more popular sites in the choice set. Tests of the statistical properties of this model show that the model's parameters are highly significant in explaining choice.

The model presented above is used to estimate the economic impact associated with the proposed changes in river flows. The economic welfare measures are calculated using the expression in equation (5). Also, as mentioned above, travel distance is converted to travel cost by applying a factor of $0.27 per mile. In an alternative calculation, the value of time was added into the economic welfare calculations by assuming that travel time is valued at $10.00 per hour.

The resulting welfare measures, for each residence zone, range from $0.46 per trip (residents of zone 8) to $3.99 per trip (zone 20). Note that while the stated preference welfare measures are higher than the revealed preference measures for each residence zone, the differences are not constant. The revealed preference measure for zone 8 is nearly 8 times smaller than the corresponding stated preference measure. On the other hand, the stated preference measure for zone 20 is only 1.7 times the revealed preference measure. The models represent a different quantification of the tradeoffs between site attributes, or scaling differences due to different magnitudes of the respective random components.

Joint Revealed-Stated Preference Analysis

The revealed preference model suffers from the fact that not all quality attributes can be included in the model because the actual data are colinear. However, the stated preference model is designed to eliminate this effect. Joint estimation of the revealed and stated preference data can remove the effect of colinearity from the revealed preference data. The joint estimation procedure can be interpreted as a type of mixed estimation (Belsley, et al. [3]; Ben-Akiva and Morikawa [4]) since the stated preference data add external information about the data and/or parameters of the model.[2] Joint estimation adds information through the addition of additional data points. However, joint estimation also makes it possible to estimate the relative scale factor for the two data series.

As described above, the scale parameter in each model was arbitrarily set to one (common in the estimation of discrete choice models). However, if one performs joint estimation it is possible to estimate the ratio of the two scale parameters in the model. The maximum likelihood process jointly determines the coefficients applied to the attributes and the relative scale factor for one part of the data that homogenizes the two variance components. In this case we chose to rescale the stated preference data to fit the revealed preference data.

Before proceeding with the joint estimation one should consider if the two sets of data are derived from some similar underlying preference structure. We investigate this issue by plotting the predicted probabilities of choice, for each site, from the stated preference model against the same information from the revealed preference. Taking the logarithms of this information produces the graph in Figure 1, in which the probabilities of site choice are estimated by residence zone. Clearly, there is a linear relationship between the log of the stated preference predicted probabilities and the log of the revealed preference probabilities. Fitted lines between these points for each residence zone yield adjusted R^2s between .297 and .588. Furthermore, a likelihood ratio test of the difference between parameters, incorporating the relative scale effect, yields a χ^2 (2 df) value of .003, implying we cannot reject the hypothesis of equal parameters. Conditional on the assumption of equal parameters, a likelihood ratio test of equal scale factors yields a χ^2 (1 df) of 294.83. The null hypothesis of equal scale factors is rejected at a 99% level (see Swait and Louviere [24] for a discussion of these hypothesis tests). We consider this to be sufficient evidence that the stated and revealed preference data contain similar preference structures and that joint estimation, including the rescaling of one of the data series, is justified.

The data used in the revealed preference analysis and the stated preference analysis were recoded so that the same units were used for both data sets (ie. effects coding rather than dummy variable coding was used for the discrete level attributes). The joint estimation results are in Table 5. The ρ^2 for this joint model was .68. All parameters had the same sign as the parameters in the stated preference model. Note that many more factors are significant in the joint model relative to the revealed preference model. This is probably because the colinearity in the revealed preference model has been reduced (or perfect colinearity no longer exists).

The welfare measures were recalculated using the parameters estimated from the joint model. These new measures are closer to the revealed preference model than the stated preference model. These results are presented in Table 5[3].

Discussion

The techniques used and findings presented in this paper should be of interest to economists for several reasons. First, as a method of valuing non-market goods, the choice experiment approach seems to be a very fruitful variant of stated preference techniques. The most common stated preference technique employed in economic analysis is contingent valuation. While contingent valuation has been shown to perform admirably in some settings many other studies question its validity (see Cummings et al. [9] or Mitchell and Carson [23]). The choice experiment approach seems to be very flexible, in terms of modeling complex tradeoffs between attributes. In this particular study, we can also show that the underlying preferences reflected in the stated preference and revealed preference models are similar. This comparison is based on identical theories of choice, the random utility model. These findings lend support to the use of this stated preference technique, at least in the measurement of use values. While others have promoted the use of stated preference techniques like conjoint analysis (Goodman [11], MacKenzie [19]) we believe that this paper presents one of the first applications of joint stated and revealed preference methods, employing these techniques, in the non-market valuation literature[4].

A second advance presented in this study is the use of the stated preference model to improve the quality of the estimates of the revealed preference model. Colinearity can be a significant problem in applications of revealed preference models, making it difficult to isolate the effects of attributes. In applied work it is often precisely this isolation of factors which is required. Furthermore, applications in non-market valuation often require simulation of conditions (attribute levels) outside the span of current conditions. Stated preference techniques can be used to analyze the response of individuals to attribute ranges not presently available.

Finally, contingent valuation has received considerable attention recently because of the controversy regarding non-use value estimates. While we present a case involving use values in this paper, an application to non-use values is relatively easy to construct. The appealing traits of the choice experiment technique (focused respondent tasks, an emphasis on trade-offs between factors, consistency with the random utility model) suggest that it may offer a valuable alternative to contingent valuation in the measurement of non-use values. This appears to be a fruitful avenue for future research.

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Table 1. List of Attributes Used in the Stated Preference Experiment

Attribute	Description	
Terrain	Flat Prairie Rolling Prairie Foothills Mountain	
Fish Size	Large Small	
Fish Catch Rate	1 fish per 4 hours 1 fish per 80 minutes 1 fish per 45 minutes 1 fish per 35 minutes	
Water Quality	Good Bad	
Facilities	Day-Use Only Limited Facility Campsite Fully Serviced Campsite	
Swimming	Yes No	
Beach	Yes No	
Distance	25 KM 50 KM 100 KM 150 KM	
Attribute	Standing Water	
Water Feature		Natural Lake Reservoir
Fish Species		Pike and Perch Pickerel, Pike and Perch
Boating		None Small Crafts Power Boats (limited) No Restrictions
	Running Water	
Water Feature		River Stream
Fish Species		Mtn. Whitefish Rainbow Trout and Mtn. Whitefish Rainbow Trout, Mtn. Whitefish and Brown Trout Cutthroat Trout, Mountain Whitefish and Bull Trout

Table 2: Coefficients of the Stated Preference Model

Attribute	Description	Standing Water[a]	Running Water[a]
Terrain[b]	Flat Prairie (=-1) versus	-.367	-.415
	Rolling Prairie (=1)	-.071 (.046)	-.100 (.042)
	Foothills (=1)	.257 (.045)	.125 (.042
	Mountain (=1)	.181 (.045)	.390 (.042)
Fish Size	Large (=1) vs Small (=-1)	.058 (.026)	.090 (.025)
Fish Catch	Fish per unit time	.062 (.028)	.105 (.026)
Fish Species[b]	Mtn. Whitefish (=-1) versus	n/a	-.275
	Rainbow Trout and Mtn. Whitefish (=1)	n/a	.064 (.043)
	Rainbow Trout, Mtn. Whitefish and Brown Trout (=1)	n/a	.107 (.041)
	Cutthroat Trout, Mountain Whitefish and Bull Trout (=1)	n/a	.103 (.042)
Water Quality	Good (=1) vs Bad (=-1)	.394 (.027)	.321 (.025)
Facilities[b]	None (=-1) versus	-.353	-.277
	Day-Use Only (=1)	-.200 (.046)	-.109 (.043)
	Limited Facility Campsite (=1)	.305 (.045)	.162 (.042)
	Fully Serviced Campsite (=1)	.248 (.045)	.225 (.042)
Swimming	Yes (=1) vs No (=-1)	.274 (.026)	.158 (.025)
Beach	Yes (=1) vs No (=-1)	.198 (.026)	.123 (.024)
Distance	Kilometers	-.007 (.0004)	-.007 (.0004)

[a] Water Feature specific (running versus standing water) coefficients are estimated for most attributes except distance. n/a indicates not applicable and n/s indicates not significant and not included in the model.

[b] Attributes with multiple levels are coded using effects codes. The base level is assigned -1 for all columns representing the remaining levels. Each column contains a 1 for the level represented by the column and a -1 for the base. The interpretation of these parameters is that base level takes the utility level of the negative of the sum of the estimated coefficients and each other level takes the utility associated with the coefficient.

Table 3: Coefficients of the Revealed Preference Model:

Attribute	Description	Standing Water[a]	Running Water[a]
Distance	Kilometers	-.0282 (0.0013)	-.0282 (0.0013)
Catch	Fish per unit time	2.0338 (0.2371)	2.0338 (0.2371)
Swimming	Yes (=0) vs No (=1)	2.7477 (0.2896)	0.9148 (0.2505)
Beach	Yes (=0) vs No (=1)	0.9918 (0.3019)	-1.955 (0.3687)
Water Quality	Poor (=1) vs Good (=0)	-.8197 (0.4941)	-3.129 (0.3749)
Boating	Unrestricted (=1) versus none	6.6620 (1.024)	1.7335 (0.2886)
	Power Boats on Lake Sites (=1) versus none	7.2496 (1.062)	n/a n/a
Water Feature	Running Water (=1) versus Standing Water	n/a	7.6178 (1.1290)
Site Constant 2	Site specific shift constant	2.8340 (0.3993)	2.8340 (0.3993)
Site Constant 13	Site specific shift constant	2.9120 (0.2920)	2.9120 (0.2920)
Site Constant 14	Site specific shift constant	2.6021 (0.2953)	2.6021 (0.2953)
Site Constant 17	Site specific shift constant	0.6878 (0.1845)	0.6878 (0.1845)

[a] Water Feature specific (running versus standing water) coefficients are estimated for most attributes except distance, catch per hour and the site specific constants. n/a indicates not applicable.

Table 4: Coefficients of the Joint Model

Attribute	Description	Standing Water	Running Water
Terrain[a]	Flat Prairie	-1.557	-1.75
	Rolling Prairie	-.300 (.194)	-.422 (.179)
	Foothills	1.09 (.193)	.527 (.179)
	Mountain	.767 (.191)	1.65 (.179)
Fish Size	Large (=1) vs Small (=-1)	.244 (.111)	.380 (.104)
Fish Catch	Fish per minute	.262 (.113)	.428 (.106)
Fish Species[a]	Mtn. Whitefish	n/a	-1.16
	Rainbow Trout and Mtn. Whitefish	n/a	.271 (.181)
	Rainbow Trout, Mtn. Whitefish and Brown Trout	n/a	.453 (.176)
	Cutthroat Trout, Mountain Whitefish and Bull Trout	n/a	.438 (.180)
Water Quality	Good (=-1) vs Bad (=1)	-1.67 (.113)	-1.36 (.104)
Facilities[a]	None	-1.51	-1.17
	Day-Use Only	-.834 (.194)	-.465 (.184)
	Limited Facility Campsite	1.29 (.192)	.684 (.176)
	Fully Services Campsite	1.05 (.190)	.952 (.178)
Swimming	Yes (=-1) vs No (=1)	-1.16 (.112)	-.670 (.104)
Beach	Yes (=-1) vs No (=1)	-.839 (.112)	-.522 (.104)
Distance	Kilometers	-.029 (.001)	-.029 (.001)

[a] Attributes with multiple levels are coded using effects codes. The base level is assigned -1 for all columns representing the remaining levels. Each column contains a 1 for the level represented by the column and a -1 for the base. The interpretation of these parameters is that base level takes the utility level of the negative of the sum of the estimated coefficients and each other level takes the utility associated with the coefficient.

Table 5: Welfare Measures from the Stated, Revealed and Joint Models

Residence Zone	Revealed Preference		Stated Preference		Joint Model	
	Travel Cost	Travel and Time Cost	Travel Cost	Travel and Time Cost	Travel Cost	Travel and Time Cost
1	0.77	1.13	4.43	6.48	0.40	0.59
2	1.55	2.26	5.67	8.30	1.16	1.69
3	1.04	1.52	4.60	6.73	0.59	0.87
4	1.24	1.81	5.18	7.57	0.67	0.98
5	0.64	0.94	4.62	6.75	0.38	0.56
6	1.59	2.33	4.63	6.79	0.68	0.99
7	1.68	2.45	5.16	7.55	0.86	1.26
8	0.46	0.68	4.29	6.27	0.21	0.31
9	0.58	0.85	4.44	6.49	0.32	0.47
10	0.66	0.97	4.33	6.33	0.33	0.48
11	0.69	1.01	4.66	6.82	0.41	0.59
12	0.53	0.77	4.64	6.79	0.35	0.51
13	2.83	4.15	6.79	9.94	2.74	4.01
14	1.48	2.16	5.20	7.61	0.85	1.24
15	1.56	2.28	5.79	8.47	1.06	1.55
16	1.20	1.76	6.55	9.59	2.02	2.96
17	1.78	2.60	7.73	11.31	2.60	3.81
18	1.97	2.88	7.08	10.36	3.28	4.80
19	2.80	4.10	7.43	10.87	4.15	6.07
20	3.99	5.84	7.96	11.65	5.29	7.73
21	2.46	3.60	8.06	11.79	2.72	3.97
22	2.00	2.93	7.05	10.32	2.04	2.98
23	1.07	1.56	7.03	10.29	1.96	2.87
24	1.05	1.54	7.27	10.63	0.96	1.41
25	0.65	0.95	5.95	8.70	0.56	0.82

Endnotes

1. Attributes with multiple levels are coded using effects codes. The base level is assigned -1 for all columns representing the remaining levels. Each column contains a 1 for the level represented by the column and a -1 for the base. For example, in the fish species case, Mountain whitefish (base) are assigned a value -1 for all 3 columns of Fish Species. The first column represents Rainbow Trout and Mountain Whitefish (coded 1) versus Mountain Whitefish alone (coded -1). The interpretation of these parameters is that base level takes the utility level of the negative of the sum of the estimated coefficients and each other level takes the utility associated with the coefficient.

2. In this case we interpret the procedure as the use of stated preference data to add information to the revealed preference estimation. However, the reverse is also possible.

3. The values in Table 5 are developed from unweighted estimation over all individuals in the sample. As described above, the respondents to the revealed preference component are the same individuals that responded to the stated preference component. In order to extend these results to provincial level aggregates, additional analysis was performed using weighted data and other forms of site attributes. These results, available in Alberta Environment [1], were based on weighted revealed preference results and unweighted stated preference results.

4. Cameron [8] presents a model which jointly estimates contingent valuation and travel cost parameters while Dickie et al. [10] have combined contingent valuation stated preference results and revealed preference results for a market good.

Stated Preference vs Revealed Preference
(25 Source locations)