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Choice Set Considerations in Models of Recreation Demand: History and Current State of the Art

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Introduction

In the past two decades, multi-site random utility models have emerged as the popular choice among environmental economists for modeling the behavior of recreation consumers. The potential for flexible patterns of substitution between various recreation alternatives, whether these alternatives are different activities or different locations to engage in a single activity, has made random utility modeling of recreation behavior the preferred alternative to traditional single good demand models. Because random utility models are driven by the pattern of substitution between recreation alternatives, the set of alternatives assumed to be available to the recreator has the potential to affect the conclusions drawn from any empirical analysis. In particular, recent research has shown that the set of alternative sites (or choice set) assumed to be available to a recreator can has a significant impact on the estimated economic value of a recreational trip. In the context of a multi-site recreation decision, the fundamental issue surrounding the definition of the appropriate choice set is, "How do we as researchers capture variation in the set of alternatives individuals consider when making recreation choices while maintaining the tractability of the estimation process and without compromising the integrity of the data and the underlying behavior?"

In an attempt to formalize the issues associated with choice set definition in the context of random utility recreation demand models and the subsequent estimation of amenity values, the National Marine Fisheries Service commissioned a workshop of experts in the field of recreation demand analysis.[1] The workshop was designed to organize the issues of choice set definition in random utility models of recreation demand, to propose a set of guidelines for the assessment of choice set issues, to design a set of research questions for future research, and to begin to address some of these issues. The following is a compilation of these questions along with brief description of the current state of thinking in the literature, and a summary of the articles included in this special issue of *Marine Resource Economics*. This is not de-

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[1] Timothy Haab of East Carolina University in consultation with Amy Gautam and Robert Hicks of the Fisheries Statistics and Economics Division of the National Marine Fisheries Service organized the workshop. It was held September 9 and 10, 1999 in Silver Spring, MD.

signed to be the final word on choice set definition in RUM models, but instead provides the current state of research in the area and provide food for thought for future research. Because we are ultimately concerned with welfare estimation in the context of recreational site choice, the body of works cited here will be biased towards recreation demand and welfare measurement studies. Where appropriate, we refer the reader to the treatment of choice sets in other fields.

The Basic Site Choice Model and the Choice Set Issue

To begin, consider the standard formulation of the recreation site choice model in which an individual is assumed to choose the recreation alternative that yields the highest level of utility from among a set of alternatives $S = \{1, \ldots, N\}$. The universal set S represents what will be called the choice set. The indirect utility function for alternative j is represented by

$$U_j(q_j, y - p_j, \varepsilon_j) = V_j(q_j, y - p_j) + \varepsilon_j \tag{1}$$

where $V_j\ (q_j, y - p_j)$ represents the observable portion of the individual's indirect utility function, with vector of quality characteristics q_j, income y, and price of accessing the site p_j, and ε_j represents factors unobservable to the researcher. Consistent with the random utility hypothesis, the recreator will choose alternative j if the utility of visiting site j outweighs the utility of visiting any other site in the choice set S. Formally, site j will be visited if

$$V_j(q_j, y - p_j) + \varepsilon_j \geq V_k(q_k, y - p_k) + \varepsilon_k, \;\; j \in S, \forall k \in S. \tag{2}$$

Because part of the indirect utility function is unobservable, indirect utility is random from the researcher's perspective and therefore must be treated as a random variable. The expected utility of a site visit on any particular choice occasion can be found by taking the expectation of the maximum utility attainable with respect to the unobservables

$$v(\mathbf{q}, y - \mathbf{p}) = E\left[\max\left\{V_k(q_k, y - p_k) + \varepsilon_k, \forall k \in S\right\}\right]. \tag{3}$$

For tractability, the error terms are typically assumed to follow a type I extreme-value distribution, and the conditional-logit model emerges [see Maddala (1983) for a complete derivation of the conditional-logit model]. Given these assumptions, the probability that individual i visits site j is

$$P_i(j) = P(j|j \in S) = \frac{e^{v_j}}{\sum_{k \in S} e^{v_k}}. \tag{4}$$

As derived here, the universal choice set S is assumed to be known to the researcher. Traditional estimation of the multinomial logit model has typically assumed that the choice set S is the same for all individuals. However, individual specific choice sets are readily incorporated into the framework provided above by simply assuming that the individual chooses the utility maximizing alternative from a subset (S_i) of the universal choice set S. Individual i, will therefore choose j if

$$V_j(q_j, y - p_j) + \varepsilon_j \geq V_k(q_k, y - p_k) + \varepsilon_k, \quad j \in S, \forall k \in S_i \tag{5}$$

From the researcher's perspective, the probability that individual *i* chooses alternative *j* can now be written

$$P_i(j) = \frac{e^{V_j(q_j, y - p_j)}}{\sum_{k \in S_i} e^{V_k(q_k, y - p_k)}} \tag{6}$$

The ultimate goal of most studies of recreation site choice is a measure of the value of recreation. For presentation purposes, we will focus on the compensating variation of a change in quality from q^0 to q^1 represented by the amount of income (CV) necessary to equate the expected maximum utilities before and after the quality change [see McConnell, Bockstael, and Strand (1991) for a complete derivation].

$$v(\mathbf{q}^0, y - \mathbf{p}) = v(\mathbf{q}^1, y - \mathbf{p} - CV) \tag{7}$$

Under the assumptions of the conditional logit model, the compensating variation of a quality change becomes

$$\begin{aligned} CV &= \left\{ CV \middle| v(q^0, y - p) = v(q^1, y - p - CV) \right\} \quad (8) \\ &= \left\{ CV \middle| \ln\left(\sum_{k \in S_i} e^{V_k(q_k^0, y - p)} \right) = \ln\left(\sum_{k \in S_i} e^{V_k(q_k^1, y - p - CV)} \right) \right\}. \end{aligned}$$

If the marginal utility of income (β_y) is not constant, then a closed form solution cannot be found and numerical approximations must be used [see for example Kling and Herriges (1999)]. If we restrict the marginal utility of income to be constant then compensating variation can be written

$$CV = \frac{\ln\left(\sum_{k \in S_i} e^{V_k(q_k^1, p)} \right) - \ln\left(\sum_{k \in S_i} e^{V_k(q_k^0, p)} \right)}{\beta_Y}. \tag{9}$$

As is readily apparent, the value of a quality change will depend on the definition of the choice set. While individual specific choice sets add a degree of complication to the estimation procedure, most software packages that can estimate conditional-logit models (*e.g.*, LIMDEP, SAS, GAUSS) readily accept individual specific choice sets. The fundamental question that must be addressed is therefore: How do we as researchers best define S_i so as to avoid the inherent biases associated with ill-defined choice sets? As Hicks and Strand (2000) explain:

> An erroneously defined choice set can have several effects in the RUM model. …[T]he probability of choosing site *j* depends on the choice set S_i; therefore, the likelihood function for the statistical model is also dependent on S_i. Consequently, a misspecified choice set can bias parameter estimates. The welfare measure…is also an explicit function of the choice set S_i. If the choice set is misspecified then serious errors in the calculation of the welfare measure could be made because incorrect parameter estimates are being used and the summation is conducted over the wrong choice set.

From this familiar framework, a number of questions related to choice set definition have arisen in the literature.

Questions Associated with Choice Set Definitions in Random Utility Models

Is Choice Set Definition an Issue?

The issue of defining the choice set has received considerable attention in other branches of economics as attention has shifted away from methodological issues surrounding discrete choice estimation and towards examining the assumptions underlying the discrete choice model. For example, Horowitz (1983) argues that it is unlikely that a high school senior who wants to go to college applies to or considers all of the institutions in the country. Horowitz proposes a cost of information approach to defining choice sets. In his econometric model, gaining information about alternatives is costly, while enlarging the choice set makes an individual better off. The model incorporates a behavioral component into the formation of the consideration set. Estimation of the model is not attempted and the paper admits that the model would be quite difficult to estimate.

There has been considerable effort devoted to choice set formation in the geography, transportation, and marketing fields. Thill (1992) provides a good overview of this literature. Manski (1977) details the biases caused by ill-defined choice sets in the random utility framework. There have been a number of other attempts at incorporating choice set formation into a behavioral model of discrete choice. For example, Horowitz and Louviere (1995) investigate the role of determining the appropriate choice set in modeling discrete choices in a marketing example. The results from Horowitz and Louviere are mixed. In one experiment they show that an endogenous choice set model provides little additional information beyond the preference information revealed by the actual choice. On the other hand, a second experiment leads to the conclusion that in certain situations, modeling the choice of choice sets may in fact provide additional information about consumer utility than does a model that does not address choice set endogeneity. In fact, Horowitz and Louviere conclude: “Two-stage decision making in which a preliminary or consideration stage precedes choice ... may be prevalent when the choice set is very large, or choice is among unfamiliar alternatives” (p. 53).

In the case of the demand for recreation, both of these conditions may hold. Researchers are usually forced to assume the set of recreation sites considered by the individual because information about the person’s choice set is not gathered in the survey instrument. The individual likely has information from which researchers could make conjectures regarding the set of sites that are relevant to a particular recreational occasion. In an early random utility recreation site choice model, Caulkins (1982) assumes that all of the sites considered in the survey instrument are relevant to the individual’s discrete choice. Hicks and Strand (2000) term this approach the Full Choice Set approach. The implicit assumption is that all recreation sites of a typical type in a defined region are relevant to the individual. Peters, Adamowicz, and Boxall (1995) have shown that this approach can introduce bias compared with an assumed true model that contains only the sites that are familiar to the respondent.

The conclusion in the recreation literature appears to be that choice set definition does matter, but only under certain circumstances. For example, Parsons and Hauber (1997) use distance to define the geographic extent of the market for recreation and find that beyond a certain threshold the welfare effects of including more distant sites are minimal. Parsons and Hauber use this result to provide a means of making a large dimension choice problem more tractable by eliminating distant sites. By reversing the logic it can be argued that for large choice set problems, the inclusion of additional distant sites will not have a large influence on welfare measures. Parsons, Plantinga, and Boyle (2000) find that narrowing choice sets through other means such as site popularity, or site aggregation can have significant welfare implications. They find that two opposing welfare effects need to be considered in the modeling of choice sets. As a choice set narrows, the effects of substitution between sites tend to be exacerbated and welfare changes due to policy changes tend to increase. However, as the choice set narrows, the population affected by any policy change decreases and thus aggregate welfare changes are smaller. Hicks and Strand (2000) find that the direction of these differing effects are difficult to predict and will likely vary depending on the policy change and the site affected. Parsons, Plantinga, and Boyle (2000) conclude, "Resolution of the correct conceptual treatment of consideration sets is certain to be important for future welfare analysis attempting to incorporate such information."

Do Existing Models Capture Choice Set Definition?

The two traditional models of recreation site choice are the conditional-logit, and the generalization of the nested logit model. The use of conditional-logit models for recreational demand analysis has been criticized on the grounds that the Independence of Irrelevant Alternatives (IIA) property should hold for the choice among recreational sites. As applied to recreational site choice, the IIA property states that the introduction of an irrelevant site should have no impact on the relative probabilities of choosing among the relevant sites. Morey (1999) states the case against the conditional-logit as follows:

> ...the I.I.A. (Independence of Irrelevant Alternatives) assumption implicit in the [Conditional Logit] model, while possibly *reasonable* when all the alternatives are recreational sites of a particular type, is not reasonable when the sites differ by type...

Morey's description explains only a part of the IIA problem inherent in the conditional logit model as applied to recreation site choice. The IIA violation implicit in the conditional logit model is exacerbated if the choice set for sites of the same type is ill defined. The focus should be on the definition of an irrelevant alternative. In their investigation of models with a large number of alternatives, Parsons and Kealy (1992) recognize the possible limitations of assuming all sites of the same type are relevant, and explain one possible bias. If a recreator were faced with the choice between a distant low quality lake, and a nearby high quality lake, the a priori expectation would be for the recreator to choose the close lake. But, if the recreator is unfamiliar with the nearby lake, and instead chooses to visit the distant lower quality lake, a behavioral model which assumes that both lakes were relevant to the site choice decision will underestimate the impact of distance (travel cost), and lake quality on the site choice decision.

In the abstract, the issue of choice set definition can be considered in the nested logit context. First a recreator chooses from among all of the possible choice set combinations and then conditional on the choice of a choice set chooses the specific alternative. This framework would eliminate the need for the researcher to specify the choice set since the probability of any particular choice set being chosen would be estimated. Such a strategy relies on the choice of choice set being observed in which case the estimation of this choice would be unnecessary (unless of course, the question of interest is how choice set choices are formulated). Despite the intractability of the formulation, the two-stage decision process (choice set then alternative) has led researchers to attempt to model how individuals formulate their choice sets and whether the two-stage decision process can be modeled explicitly.

Can Sites Be Ruled Out Based On Demographics Or Other Determinants?

A number of recent studies have attempted to narrow choice sets in recreation site choice models by ruling out sites based on individual or site specific characteristics. Parsons and Hauber (1997) use distance from sites to rule out sites considered out of the geographic market. As stated previously, they find that distance based choice sets can be successful in reducing the dimension of the site choice problem provided valid substitute or complementary sites are not mistakenly excluded. Parsons, Plantinga, and Boyle (2000) define five different choice set selection mechanisms for analysis of lake choice in Maine. They use choice sets based on the full set of lakes in Maine (814), geographic aggregation for sites outside the policy area of interest (a subset of 25 lakes), complete aggregation of all sites outside the policy area, the ten most popular sites outside the policy area, and excluding all sites outside the policy area. The first three choice models include all of the sites through various aggregation schemes. They call these 'targeted aggregation' schemes and differentiate them from the ad hoc site aggregation schemes used by Parsons and Needelman (1992), Feather (1994), and Kaoru, Smith, and Liu (1995) to reduce the dimension of the choice problem. The popular site and the site exclusion models use restricted choice sets outside of the policy area to reduce the dimension. Parsons, Plantinga, and Boyle (2000) find that welfare estimates vary considerably across choice set and aggregation treatments.

Each of these studies uses site and individual characteristics as guidelines for the researcher to define the appropriate choice set and reduce the estimation burden. Alternatively, Peters, Adamowicz, and Boxall (1995) allow survey respondents to first define the set of sites they 'considered' before choosing the actual site visited, thereby allowing the respondent to define the choice set rather than the researcher. Hicks and Strand (2000) use a similar approach, but rely on the survey respondent's familiarity with sites instead of the sites they considered. By relying on familiarity rather than consideration, Hicks and Strand eliminate the possibility that respondents might not 'consider' taking a trip to a poor quality site with which they are familiar. In such an instance the poor quality site is a candidate for the choice set but would be ruled out under the Peters, Adamowicz and Boxall approach. While appealing because these methods allow the individual to define the choice set that will determine the behavior we are trying to model, the necessary information (familiarity or consideration) is not readily available or expensive to collect in many recreation demand applications (for example the case of a large number of alternatives).

Still other approaches have used clustering techniques relying on geographic and other information about individuals. Using information about where individuals live, geographic attributes of the recreational region, and/or the individual specific information might allow the researcher to narrow the choice set by examining where 'similar' individuals recreate. For example, recent work by Chapman (1999) used GIS clustering techniques to define individual specific choice sets. He found that persons living in particular towns in South Texas tended to fish in the same general area. However, participants from other towns did not tend to cluster and chose to recreate at a much wider range of sites. For these persons, the choice set was assumed to contain nearly all sites. A pooled model that defined individual specific choice sets based on the clustering technique was estimated. The results were nearly the same as a model containing all sites for all individuals. Similar work by Jakus *et al.* (1997) used clustering techniques for lake recreation in Tennessee. Rather than cluster by town, they noted that individuals nearly exclusively recreated in their region of the state. Regions were defined by well-defined mountain terrain separating the various areas of the state. The paper hypothesizes that crossing over these mountains added significant travel time and tended to keep people in their region of residence.

In attempt to alleviate the problem of collecting familiarity information on all relevant sites, Haab and Hicks (1997) extend models proposed by Manski (1977), and Swait and Ben-Akiva (1987), which allow the choice set to be internally estimated as a function of individual and site specific characteristics. The Haab and Hicks model can be thought of as an application of the nesting model described above in which individuals first choose a choice set and subsequently choose a site. Their model then assumes an individual specific distribution function for the universal choice set which represents the probability that each site is included in the individual specific choice set. The Haab and Hicks model suffers from a severe dimensionality problem. For a universal choice set S with n possible sites, the number of possible subsets (candidate choice sets) is $2^n - 1$ if we exclude the null set. For example, with 10 possible sites, there is 1,023 possible choice set combinations that must be estimated. In a limited application, Haab and Hicks find that the endogenous choice set model can perform significantly better than more traditional site choice models.

Is Choice Set Definition a Data Collection Issue or an Econometric Issue?

The discussion above leads to the inevitable conclusion that many issues of choice set definition remain to be resolved. It is clear that under at least some circumstances, the definition of the relevant choice set can have a significant effect on the estimation of welfare from recreation site choice models. Significant problems remain however in determining how recreators form their choices as to where to recreate and how best to model those choices from a researchers point of view. If individuals do make decision in a two-stage framework such as that proposed by Horowitz and Louviere (1995), then the question remains: How do we as researchers get individuals to reveal their choice set to us? Can simply asking individuals which sites are in their choice set be a feasible solution? Are individuals capable of revealing this information, or is the idea of a choice set an artificial construct that gives researchers a more convenient means of estimating econometric models? If so, what is the appropriate econometric model, or more fundamentally, do existing econometric models adequately address the site choice issue?

As the computational techniques available to researchers expand, it is possible to introduce more flexibility into the site choice model. For example, the progression from the multinomial/conditional logit RUM to the nested RUM [see Morey (1999) for an overview] to the even more flexible multinomial probit RUM has allowed researcher to introduce substitution patterns between sites that were previously intractable. With this additional flexibility comes the possibility that choice set modeling may be incorporated into more general econometric models. Recent advances in the modeling of demand systems with corner solutions may lead to models (Herriges, Kling, and Phaneuf 1999) in which choice set definition is a natural consequence of the behavioral model proposed.

Articles in this Special Edition

For the most part, the articles approach the problem of defining the choice set with no more information than is commonly found in recreation demand studies. That is, there is no stated preference data about sites individuals consider or are familiar with [for an exception see Parsons, Massey, and Tomasi (2000)]. In general these studies demonstrate that a researcher's definition of the choice set does make a difference for estimated parameters and changes in welfare. Each paper takes a unique approach to the issue of defining choice sets, and a holistic examination of these papers may yield useful information for this problem.

Whitehead and Haab (2000) investigate choice set issues in the context of a large national survey of recreational anglers conducted yearly by the National Marine Fisheries Service. The data used for this study provide a practical setting to investigate these issues since the regional survey of the United States has a large geographic extent and resource managers use such data to value recreational marine fishing resources and policies. The paper examines how welfare and parameter estimates are effected when limiting the choice set either by distance [see Parsons and Hauber (1998)] from an individual's home or by quality. Their paper demonstrates that limiting the choice set based upon distance going from all sites down to sites within 180 miles from respondents homes yield only modest changes in welfare estimates when investigating quality changes or site closures. For choice sets limited by quality, results differ according to the definition of the fishing quality variable in the model.

Parsons, Massey, and Tomasi (2000) combine data on actual site choices made by individuals and stated information about sites considered or familiar to individuals. They argue that rejecting sites based upon familiarity or consideration might be confusing low-utility sites with unfamiliar sites. For beaches in the Mid-Atlantic area people are not likely to know many of the details about sites with relatively low utility, but do know of their existence. Two new approaches are developed that include all sites in the choice set; however, distinctions are made in the individual's utility function for familiar and favorite sites. The results show that there is considerable variation in parameter and welfare measures across a basic model (that includes all sites in the choice set), the Familiar Sites Model, the Favorite Sites Model, and models based on Peters, Adomowicz, and Boxall (1995) and Hicks and Strand (2000). Their findings support the notion that conventional discrete site choice models may understate recreational values. They show some differences between models that eliminate unfamiliar sites from the choice set [as in Hicks and Strand (2000) and Peters, Adomowicz, and Boxall (1995)] and models that included unfamiliar sites, but allowed the utility function to vary by familiarity level.

McConnell and Tseng (2000) warn against picking and choosing stated preference information in an applied setting. Instead, they propose using all sites in the choice set and developing a more flexible econometric model to capture the choice set effect. For this purpose, they develop a random parameters logit (RPL) model and estimate it over the universal choice set. The results show that the random parameter flexibility in a logit context yields different results than a standard logit model of site choice—suggesting that the flexibility afforded by the RPL model may be advantageous in a site choice model. Additionally, comparing an RPL using the universal choice set and an RPL using sampled alternatives from that set yields results that are similar.

MacNair and Cox (2000) also view the issue of choice set definition in random utility models as one of model flexibility rather than ad hoc specification of the traditional random utility model. In a vein similar to the McConnell and Tseng (2000) random parameter logit model, MacNair and Cox develop a flexible heteroskedastic nested RUM that allows the substitution patterns between nests to vary according to individual specific characteristics. They find that incorporating demographics into the nesting structure in addition to the alternative choice yields higher explanatory power and significantly different changes in site choice predictions.

Phaneuf and Herriges (2000) take a slightly different modeling approach. Instead of focusing on discrete site-choice decisions made by recreators, they focus on trip decisions over a season. Using a Kuhn-Tucker demand system approach that accounts for corner solutions for sites that are not visited, they argue that the problem of defining the choice set is comprised of two issues- the horizontal scope of the market: the necessary range of activities should be included in recreation demand models to capture relevant substitute effects, and the geographic extent of the market: the size of the area considered when choosing a site. Both of these issues, as the paper points out, have implications for corner solutions in the Kuhn-Tucker model. The empirical model examines several issues surrounding choice set definition including geographic aggregation, geographic extent of the choice set, and scope of the choice set. The results are similar to the discrete site-choice models found elsewhere in this issue. Site aggregation tends to decrease welfare estimation regardless of scope or welfare change scenario being considered. Limiting the geographic scope tended to decrease welfare for most cases though it depends on the sample and sites being eliminated.

Instead of looking at the degree to which the erroneous inclusion or exclusion of recreational sites affects welfare estimates from site-choice models, Jones and Lupi (2000) investigate the effect of changing the set of substitute activities on welfare measurement in this context. Their analytical analysis predicts “welfare calculations with a site-choice travel cost model that omits relevant substitute activities will tend to underestimate gains and overestimate losses for a fixed sample and a fixed set of model parameters.” They conclude that the degree of bias introduced by an ill-defined substitution set is an empirical question that will vary on a case-by-case basis. In an application to trout and salmon fishing on the Great Lakes, Jones and Lupi find that under most scenarios, models that include only the activity of interest yield similar welfare measures to those models that include a large number of substitute activities. They are careful not to generalize their results beyond the current application.

Conclusions

Because of the timeframe, and nature of the workshop for which the articles in this special issue were collected, the articles have a decidedly econometric bent to them. A common question throughout these articles is: given current data or current data collection techniques, what can we do to incorporate individual specific choice sets without imposing excessive structure on the data? While econometric solutions to the problem appear to offer promise, additional consideration should be given to the implication of the empirical findings in this issue on data collection efforts in the future. As is evidenced by the wide variety of methods and conclusions drawn herein, a complete understanding of how individuals develop the set of alternatives they consider is elusive.

Given current computational power and the promise of future power, the ability of econometric packages to handle larger and more flexible specifications will give researchers more degrees of freedom in estimating site-choice models. However, computational power does not supplant the need for careful survey design and data collection efforts to fully understand how individuals form their choice sets, and how those choices change with changes in environmental amenities. Without careful attention to issues such as the horizontal and geographic extent of the market, perceptions versus measurable behavior, and familiarity with sites versus consideration of sites, econometric models only serve to allow the researcher more modeling flexibility. Future efforts into the understanding of choice set issues in recreation demand modeling should take the empirical results described in this special issue and apply those to new survey design and data collection efforts.

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