# SEGMENTING OF EMPIRICAL ESTIMATES OF CHOICE MODELS

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**Abstract:** Managers are often interested in determining how different types of people will respond to alternate management strategies. Preferences for multiple-objective strategies can be estimated using choice models. Respondents can then be segmented according to their preference structures by techniques such as discriminant analysis, cluster analysis, and subsampling. The most appropriate technique depends on the needs of the analyst or manager and the sample design used. Limitations resulting from the initial sample design of choice experiments are discussed.

## Introduction

Choice modeling has become a popular tool for estimating and understanding values and preferences associated with decisions concerning natural resources. Managers and society must consider diverse objectives such as timber harvesting, various types of outdoor recreation, wildlife habitats, aesthetics, and ecological concerns. Decisions are increasingly complex as the number of objectives and concerns multiply. Since most of these goods are not traded in markets, their relative values can be difficult to ascertain. The situation is further complicated by the use of different units of measure and the fact that values and relative weighting for many goods and benefits are context specific with respect to time, location, and sociopolitical factors. Choice models offer a means of estimating relative values.

Managers also may be interested in determining how different types of people will respond to alternate management strategies. It may be important to know whether a chosen strategy represents a consensus among stakeholders or a midpoint between polar views. Various segmenting techniques are available to identify different viewpoints and values, though their availability may be limited by the initial sample design.

## Choice Models

There are many variations of choice models. Generally, revealed preference models rely on preferences and relative values that have been "revealed" during past behaviors. Stated preference models rely on data obtained through surveys of respondent choices that they "state" are their preferences. Frequently stated choice surveys solicit responses to hypothetical depictions of scenarios or management alternatives.

Conjoint analysis, a term used by marketing researchers, refers to analysis of data obtained from surveys in which respondents choose between alternative products or scenarios that display varying levels of selected attributes (Green et al. 1988). The choices involve alternatives that include different levels for each of a group of attributes. Thus, the respondent indicates his or her preference or value for an attribute level within the context of (or "conjointly" with) all other attributes or objectives. The utility of each attribute can be inferred from the respondent's overall evaluations. These partial utilities or "partworths" indicate the relative importance of each attribute's contribution to overall preference or utility. They can be combined to estimate relative preferences for any combination of attribute levels.

Conjoint techniques are well suited for soliciting and analyzing preferences in environmental decisions that frequently entail tradeoffs between costs and benefits that are not represented efficiently in market transactions. For example, Opaluch et al. (1993) described an approach that used paired comparisons to rank potential noxious facility sites in terms of social impacts. Dennis (1998) used a conjoint ranking survey to solicit public preferences for various levels of timber harvesting, wildlife habitats, hiking trails, snowmobile use, and off-road-vehicle (ORV) access on the Green Mountain National Forest, and Lawson and Manning (2002) used a stated (dichotomous) choice model to analyze tradeoffs among social, resource, and management attributes of the Denali wilderness experience.

Choice experiments can be designed and analyzed in many ways. Respondents may be asked to indicate their preferences by choosing one of two or more options, ranking several options, or

**Table 1. — Logistic regression model (n=1811) comparing likelihood of beach use and non-beach use based upon the influence of demographics and activity preferences.**

| Variable | Odds Ratio | Std. Err. | z | p>\|z\| | 95% Conf. Interval | |
|---|---|---|---|---|---|---|
| Age 18-29 | 1.451179 | .2704393 | 1.998 | 0.046 * | 1.007146 | 2.090978 |
| Age 30-39 | .865539 | .1528429 | -0.818 | 0.414 | .6123157 | 1.223482 |
| Age Missing | .499970 | .1443317 | -2.401 | 0.016 | .2839346 | .8803784 |
| Age 50-64 | .426565 | .0813603 | -4.467 | 0.000 * | .2935168 | .6199235 |
| Age 65 + | ..396793 | .1117294 | -3.283 | 0.001 * | .228498 | .6890431 |
| Non-white | .648328 | .0846806 | -3.318 | 0.001 * | .5018988 | .8374783 |
| Race Missing | .553262 | .2009314 | -1.630 | 0.103 | .2715158 | 1.127371 |
| Female | .865311 | .1048385 | -1.194 | 0.232 | .6824062 | 1.097239 |
| < High School | .619171 | .118886 | -2.497 | 0.013 * | .4249845 | .9020874 |
| College Grad | 1.222347 | .1596248 | 1.537 | 0.124 | .9463182 | 1.578890 |
| Disabled | .598790 | .1127542 | -2.723 | 0.006 * | .4139904 | .8660815 |
| Dis Missing | .692636 | .9462508 | -0.269 | 0.788 | .0476024 | 10.07816 |
| Coastal | 2.017702 | .2751331 | 5.148 | 0.000 * | 1.544498 | 2.635885 |
| Part-time | 1.363170 | .2653801 | 1.591 | 0.112 | .9307636 | 1.996461 |
| Retired | .6972371 | .1734442 | -1.450 | 0.147 | .4281897 | 1.135337 |
| Unemployed | .8232953 | .1365774 | -1.172 | 0.241 | .5947697 | 1.139626 |
| Work Missing | .6898237 | .3655598 | -0.701 | 0.483 | .2441513 | 1.949024 |
| Non-Beach | 1.2335700 | .1596492 | 1.622 | 0.105 | .9571958 | 1.589742 |
| Beach Missing | .0456670 | .0111792 | -12.608 | 0.000 | .0282638 | .073786 |
| <$50K | .9197644 | .1436666 | -0.535 | 0.592 | .6772039 | 1.249205 |
| > $100K | 1.5393100 | .4122901 | 1.610 | 0.107 | .9106253 | 2.602032 |
| $ Missing | .8129619 | .1368678 | -1.230 | 0.219 | .5844731 | 1.130774 |

* Significant at alpha .05

assigning numerical ratings to each option. Numerical ratings provide the most information but also place the greatest cognitive demands on respondents. Green (1974), Green and Srinivasan (1978), Louviere and Woodworth (1983), and Louviere (1988) provide information on experimental design in the context of conjoint analysis.

A random utility model generally is used to explain preferences in choice modeling. When presented with a set of alternatives, individuals are assumed to make choices that maximize their utility or satisfaction. The utility that the ith individual derives from the jth alternative ($U_{ij}$) can be represented as:

$$U_{ij} = X'_{ij}ß + e_{ij} \quad (1)$$

where $X_{ij}$ is a vector of variables, which may include transformations of variables, that represent values for each of the five attributes of the jth alternative to the ith individual; ß is a vector of unknown parameters; and $e_{ij}$ is a random disturbance, which may reflect unobserved attributes of the alternatives, random choice behavior, or measurement error. A respondent's utility level ($U_{ij}$) for each alternative is not observed, but a rating ($r_j$) or other choice representation is observed that is assumed to proxy for his or her underlying utility.

Following McKenzie (1990, 1993) and others, the analytical capabilities of the conjoint rating model can be illustrated by assuming that rating ($r_j$) can be modeled as a linear combination of the variables representing the attribute levels. Quadratic terms can be included to examine nonlinear relationships among the variables (increasing or decreasing marginal returns); they are not included here to simplify interpretation.

$$r_j = a + b_1x_{1j} + b_2x_{2j} + ... + b_nx_{nj} \quad (2)$$

The estimated partial utilities are the linear effects ($b_n$'s) of a discreet change in the level of the associated attribute on overall preference (n references attributes). Relative overall preference for any alternative (combination of attribute levels) can be determined by summing across Equation 2. The marginal rate of substitution (MRS) is the rate at which an individual is willing to trade one good

for another while remaining equally well off (Nicholson 1978). The MRS or acceptable tradeoff of one attribute for another is determined by the ratio of the marginal responses. Setting the total differential of (2) to the point of indifference and solving yields the marginal rates of substitution or the acceptable tradeoffs for the respective attributes:

$$dr_j = b_1 dx_{1j} + b_2 dx_{2j} + \ldots + b_n dx_{nj} = 0 \qquad (3)$$

$$dx_{1j} / dx_{2j} = - b_2 / b_1$$

Conjoint models may be estimated in a number of ways depending on the experimental design and desires of the analyst or manager. McKelvey and Zavoina (1975) developed a polychotomous probit model to analyze ordinal level dependent variables such as those obtained in a ranking survey. Logit techniques also are available. Although not theoretically correct, some statistical packages (e.g., SPSS) use an ordinary least-squares procedure for estimating parameters of conjoint models. The belief is that this relatively simple technique provides estimates that are useful to field managers. Although estimates differed slightly, all substantive conclusions remained similar when I compared an ordinary least-squares approach with the ordered probit technique developed by McKelvey and Zavoina (1975) using data collected during the public involvement phase of a National Forest planning effort (Dennis 1998).

**Survey Design**

An important consideration in designing conjoint surveys is determining the number of attributes and possible levels that comprise an alternative. The needs of the decisionmaker, cognitive burden on respondents, and survey medium must be considered. Optimally, an orthogonal survey design can be used. An orthogonal plan allows estimation of all main-effects components over the entire range of attribute combinations with the least number of trials. Thus, the analyst obtains high leverage between the options actually evaluated by respondents and those that can be analyzed after the evaluation. Dennis (1998) used an orthogonal plan that required individuals to rank 18 alternate National Forest management scenarios during public involvement sessions. Each alternative was depicted by one of three levels for five attributes (timber harvesting, wildlife habitats, hiking trails, snowmobile trails, and off-road-vehicle access). An orthogonal design also allows estimation of partial utilities or a preference structure for each respondent. These individual estimates can then be used to segment or stratify respondents according to their preferences.

A full orthogonal design may not be practical if it stretches the cognitive ability of the respondents. If there are numerous attributes or levels, a full orthogonal design may require too many scenarios for respondents to choose among. Also, it may not be practical to ask respondents to choose among many scenarios in a mail survey or if time is limited. Dennis et al. (2000) and Stevens et al. (2000) used mail surveys to elicit conjoint responses with respect to multiple-objective ecosystem management on private forests. In each case, respondents were asked to rank five scenarios.

**Segmenting Respondents by Preferences**

Just as a company does not want to design or market a product in a way that pleases an average but possibly nonexistent consumer, resource managers need to understand how their decisions will be perceived by different groups of stakeholders so that they can target information and design programs effectively. In some instances, it may be important for managers to know whether a proposed management alternative represents a consensus among groups of stakeholders or a midpoint between polarized subgroups. At which points are they polarized and are there similarities in values that might achieve a compromise?

Partial utilities can be estimated for each respondent with an orthogonal survey design. Cluster analysis, a multivariate procedure for detecting groupings within a data set, can be used to explore preference or value differences among subgroups of the respondents. The clustering variables are the estimated conjoint coefficients (partial utilities). Respondents with similar preference structures are identified and clustered together. Discriminant and other analytical techniques can then be used to characterize the respondents in each segment (cluster) by differences in demographic profiles, attitudes, or other available information. These techniques were used to identify and characterize two groups of respondents with different

preferences toward attributes of a previously mentioned National Forest planning effort[1]. An alternate plan is to divide the sample into groups based on demographics or other available data, estimate separate models for each subgroup, and compare the results. This strategy may require a larger sample size but is particularly useful if an orthogonal survey design is not practical.

**Summary**

Choice modeling techniques are flexible and can be used in a variety of situations to solicit and estimate preferences and values in multiple-objective environmental decisions. The estimated partial utilities indicate the relative contribution of a particular attribute and level to overall satisfaction with an alternative. The desirability of any possible alternative can be obtained by summing the partial utilities. The MRS or acceptable tradeoff between one attribute and another also can be determined. Segmenting techniques can be used to identify and understand differences in respondent preferences.

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