A Comparison of Conjoint Ratings and Rankings: An Application for Passive Use Values of Forest Health

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Abstract

This paper tests the equivalence of conjoint ratings and rankings to estimate the values of prevention of forest pest infestations. It was found that rankings constructed from ratings were not statistically different from actual rankings. This implies that the easier ratings format can be used in conjoint analysis.

Introduction

Forest health is an important issue facing land management agencies. Disagreement exists as to the exact definition, but forest health can be said to include protection from catastrophic insect and disease outbreaks. Healthy forests have characteristics of public goods. They protect water quality and provide wildlife habitat, recreation settings, and many passive use values. Estimating these non-market values is an important part of land management. Further, healthy forests have multiple attributes. This paper represents one of the first applications of conjoint analysis as a tool to estimate the passive use values of forest health.

Conjoint analysis (CJ) has been used most often in marketing research, and is only recently being applied to natural resource valuation. CJ uses a survey method where a respondent is presented with a set of options. These options are differentiated by a bundle of attributes, including a price. The respondent is asked to express preferences for these options, usually by rating, ranking, or by selecting the most preferred.

CJ most closely resembles discrete choice contingent valuation where a respondent is asked to choose between paying a price specified by the researcher for a non-market good or foregoing the good. In a CJ experiment, the researcher seeks to determine the probability that a respondent will choose one member of the choice set, and to examine the role of the attributes in that choice (Louviere, 1988). Louviere defines a model of decision making in which the utility a consumer receives from a choice can be derived from the relationship between the levels of attributes associated with the choice, the consumer's beliefs and judgements about these levels, and the consumer's expected "part worth" utility from the level of each of the attributes associated with the choice.

Attribute values can be estimated by asking an individual to compare two bundles. Two attributes in each bundle could (holding all other attributes constant) be varied in opposing directions to reach a point of equivalent utility (where the individual is indifferent between them). The marginal rate of substitution between attributes can be derived from the ratio of the marginal utilities of each bundle. Using the price of each bundle, an indirect utility function can be derived by varying price and another attribute to achieve equality between the two bundles. This marginal rate of substitution represents the marginal value of the attribute.

Non-market valuation has been conducted for decades using several techniques (Mitchell and Carson, 1989). Experimental CJ most closely resembles the direct or contingent valuation method (CVM). Within the CVM there are several formats. Much debate has been carried on as to which format best achieves the objective of inducing the respondent to reveal his true willingness to pay (or willingness to accept compensation) for a non-market good. The more closely a researcher can come to emulating "real world" scenarios the more likely it is that a respondent will give a meaningful reply to a CVM question. Consumers are most familiar with paying a pre-determined price for private goods, so a question which asks a respondent to "name your price" (such as open ended and payment card CVM formats) may be so unfamiliar that respondents are unable to give meaningful answers. Dichotomous choice, which offers a respondent a "take it or leave it" choice where the public good is offered for some specified price, is more familiar and may be easier for the respondent to answer.

Taking this emulation of the real world even further, a consumer who is considering making a purchase will usually have several "brands" to choose from. These brands will have different attributes and/or levels of attributes, among them a price. A consumer will weigh each brand and its set of attributes to determine which most fully meets his needs and budget constraint. If a public good is being offered to a consumer for "purchase" he may feel most comfortable if the choice involves selecting from among different options.

CJ has been extensively applied to predict market behavior. It is only recently being used to estimate values for non-market goods. Lareau and Rae (1989) use CJ to estimate willingness to pay to reduce diesel odors. Gan and Luzar (1993) apply CJ methods to estimate the value of waterfowl hunting. Revealed preferences and stated preferences for waterbased recreation are compared via CJ by Adamowicz et al. (1994). Stevens, et al. (1997) examine the value of groundwater protection programs using a CJ experiment. Zinkhan et al. (1994) use CJ to estimate the values of forest management and Garrod and Willis (1997) estimate the non-use benefits associated with forest biodiversity.

Mackenzie (1992) uses CJ to estimate the value of attributes associated with waterfowl hunting trips. Using the negative ratio of the coefficient on each non-cost attribute over the coefficient on cost, a marginal value was estimated for each attribute:

$$MV_i = -\frac{\beta_i}{\beta_{cost}}. \qquad \text{Eq. (1)}$$

Mackenzie (1993) compares marginal values from four models constructed from the ratings given for each of the trips (ratings, along with implied rankings, pairwise comparisons, and binary preferences constructed from the ratings).

In most of the applications above, marginal attribute values are calculated using Equation 1. While there are implicit prices, these marginal values may not reflect respondents' maximum willingness to pay for the change in each attribute holding utility constant (compensating variation). Roe et al. (1996) show that by including an option which represents the status quo and examining the difference in ratings between this status quo and an alternative, CJ can yield estimates of compensating variation.

Application of Conjoint Analysis to the Valuation of Forest Health

This study compares actual rankings, rankings constructed from ratings and ratings differences. These data were analyzed using the ordered probit functional form:

$$P_i = \frac{1}{\sqrt{2\pi}} \int_{-\infty}^{\beta_1+\beta_2 X_i} e^{-t^2/2}\, dt. \qquad \text{Eq. (2)}$$

Since neither ratings nor rankings are continuous or cardinal variables, the ordered probit functional form is the appropriate statistical analysis technique.

The comparisons of ratings and rankings by Mackenzie and Roe et al. discussed above both use rankings *constructed* from ratings, rather that *actual* rankings from independent samples. These papers found that the construction of the preference variable did produce different results. This paper will compare similarly constructed rankings with actual rankings in two <u>independent samples</u> of respondents with both compared to ratings differences. It has been argued that task complexity increases as one moves from a "choose one" format, to a rating format, to a ranking format (Alwin and Krosnick, 1985; Feather, 1973). If the ordinal preferences (rankings) obtained from a relatively easy task (ratings) are determined to be the same as those obtained by asking for rankings directly, one could safely recommend that researchers use the ranking technique in order allow respondents to perform more comparisons or perhaps increase response rates for the same number of comparisons.

We will first address the hypothesis that the different question formats produce the same coefficients using a likelihood ratio test.

$$H_O: \beta_{rank} = \beta_{constructed\ rank} \qquad \text{Eq. (3a)}$$

$$H_A: \beta_{rank} \neq \beta_{constructed\ rank} \qquad \text{Eq. (3b)}$$

The next hypothesis tested is the effect of question format on the marginal values of forest health attributes. Using Equation 1, we estimated the marginal values obtained from the ratings difference model, the constructed rankings models and the actual rankings model. The following hypothesis is tested:

$$H_O:\ -\frac{\beta_{i_{ratings\ diff.}}}{\beta_{cost_{ratings\ diff.}}} = -\frac{\beta_{i_{constructed\ rank}}}{\beta_{cost_{constructed\ rank}}} = -\frac{\beta_{i_{rank}}}{\beta_{cost_{rank}}} \qquad \text{Eq. (4a)}$$

$$H_A:\ -\frac{\beta_{i_{ratings\ diff.}}}{\beta_{cost_{ratings\ diff.}}} \neq -\frac{\beta_{i_{constructed\ rank}}}{\beta_{cost_{constructed\ rank}}} \neq -\frac{\beta_{i_{rank}}}{\beta_{cost_{rank}}} \qquad \text{Eq. (4b)}$$

One issue which must be addressed when one constructs rankings from ratings is the occurrence of ties. When asked to give independent ratings to a set of alternatives it is possible that a respondent may give two or more alternatives the same rating. These ties may be true indifference, or an indication that the two alternatives are so close that the true rating for each falls within the same interval on the rating scale. For this study, we assume that the tied ratings indicate indifference. In the case of a tie the options were given the same rank, skipping the next lowest rank. In order to examine the influence ties may have had on the results, the model was also run without ties. First, any respondent giving a tie to any two alternatives within a scenario was eliminated from the analysis ("no ties 1"). Second, only those scenarios with tied ratings were eliminated ("no ties 2").

Forest health is a non-market good which is composed of multiple attributes. Management to maximize one or more of these attributes may lead to changes in the levels of other attributes. Public preferences for the various amenities of healthy forests can be expected to be quite diverse. One aspect of forest health is the prevention or eradication of insect infestations. Pest management involves a variety of activities each with different levels of success and different extraneous consequences. It can be expected that different members of society may place different weights on the various attributes of a pest management program. Given this set of circumstances, CJ may be the most appropriate tool to estimate the value of management activities to protect or restore forest health.

This paper presents the results of a CJ study examining alternative management programs for three forest pests in the United States. The gypsy moth is an introduced pest, which has little effect on commercial timber, but does have a high impact on ornamental trees and trees in popular recreation areas in the Northeast (Doane & McManus, 1981; USDA Forest Service, 1995). The second scenario is the western spruce budworm. This insect is native to most fir stands in the western US, and has a large impact on commercial timber in the Pacific Northwest (Brookes et al., 1987; USDA Forest Service, 1989). The final scenario is the southern pine beetle, another native insect, which has impacts on commercial timber in the Southeast (Thatcher, et al., 1981; USDA Forest Service, 1987).

The three insect infestation scenarios were presented in a questionnaire mailed to 2400 households. The sample was concentrated equally in the three geographic regions most affected by the pests (the Northeast, Oregon and the Southeast). The same questionnaire (with all three scenarios) was sent to each region. Within each regional sample, half received the ranking version and half received the rating version.

The first part of the questionnaire consisted of a series of Likert-scale questions dealing with the appropriateness of various forest health management techniques practiced by foresters on both private and public lands. Following these questions was a page containing information about trade-offs in forest health management. The next section of the questionnaire contained the three forest pest scenarios. Each scenario contained a brief description of the insect, including its area of impact, and the effects of an uncontrolled infestation. Next was a description of three management options, the first of which was "no action" (the status quo), followed by a moderate pest management option, then an intensive management option. The three management options were then compared in a table showing the expected effects over the next 15 years: the area infested, changes in non-target insect populations, changes in insect-eating bird populations, water resource effects, changes in recreation use and changes in commercial timber. Finally the respondent is asked to either rate (on a ten-point scale) or rank the three options. The final section asked demographic questions. This questionnaire was developed with input from foresters and entomologists in the forest health field. The survey instrument was refined using the input of focus groups and a pre-test conducted in the three survey regions.

Response rates were lower than usual, with an overall response of 32% (32% for the rating version and 33% the ranking version). The similarity of response rates is key for our methodological comparisons. While the sample may not be representative of the population, the equivalent response rates suggest that they are similar to each other. T-tests of the demographic characteristics (sex, age, education and income) indicate that the two samples are not statistically different at the 10% level.

Results

Several models were examined, with different combinations of attributes. Correlations among some of the attributes (which are correlated in nature in some cases) prohibited the use of all of the attributes in one model. The final model uses the following as independent variables: the number of acres expected to be infested within 15 years of implementation of the program, the cost per household, expected changes in commercial timber harvests and a dummy variable indicating whether the pest was introduced or native to the region.

$$Preference = \beta_1 + \beta_2 cost + \beta_3 acres + \beta_4 timber + \beta_5 native \qquad \text{Eq. (5)}$$

Table 1 contains the regression results for each of the models.

Table 2 displays the results of the likelihood ratio tests. The null hypothesis that the coefficients for the constructed ranks and actual ranks are equal cannot be rejected for any of the models. The rating and ranking formats yield similar behavior (coefficients) and, thus similar marginal values for the attributes. This is important because one can choose the response format which is easiest for the respondent without changing the outcome.

Marginal values for the ratings difference model, the three constructed ranking models and the actual ranking model were estimated using Equation (1). Since the marginal values are the ratios of random variables, we constructed confidence intervals via the method derived by Fieller (1932) and used by Mackenzie (1992, 1993). The marginal value for attribute *i* is $-\beta_i$

/$\$_{cost}$, we can express this as $\$_i + \$_{cost}MV = 0$. The confidence interval can be estimated from the quadratic roots of:

$$\frac{(\$_i \ \% \ \$_{cost}MV_i)}{(F_i^2 \ \% \ 2F_iF_{cost}MV_i \ \% \ F_{cost}^2MV_i^2)^{0.5}} > t. \qquad \text{Eq. (6)}$$

The results are shown in Table 3. For acres infested and for timber values the 90% confidence intervals overlap for all five models. As the number of acres infested increases, preference (marginal values) for the management option decreases. This is reflected clearly in the negative marginal values. The confidence intervals for this attribute do not include zero. The confidence intervals for timber, however, do include zero, indicating that the marginal values are not significantly different from zero. The marginal values for "native" are somewhat confounding. For the ratings difference model the marginal value is positive, while it is negative for the rankings model and for the three constructed rankings models. The confidence intervals for all of the forest health management attributes overlap (with the exception of "native") indicating that, to some extent, the response formats do produce similar marginal values. This has implications for research, as one may use a format which is easier for respondents.

Conclusions

CJ has been used widely in market research, but less work has been done using CJ to value non-market goods. Further, most non-market research using CJ has been in the valuation of recreation amenities. There are few applications for the estimation of passive use values. The methodological tests performed will serve to increase the usefulness of the CJ technique as a tool to estimate values for non-market amenities. Our finding that ratings and rankings data from independent samples produce the same marginal values implies that the easier task of ratings can be used in future CJ studies. As with any new technique (or in this case newly applied to the problem), refinements are always needed to improve its performance.

There is a relatively small body of literature examining the non-commodity values associated with forest health. This literature has been reviewed and compiled by Rosenberger and Smith (1997). We found that households valued a reduction in the number of forest acres infested, even in regions far enough from home to make recreation use unlikely. We also found that the value of protecting commercial timber is not significantly different from zero. Examining the separate attributes of land management actions may offer greater insight into the values held by people for public lands, and help determine appropriate management alternatives.

Table 1 - Results of Ordered Probit Regressions

	ratings difference	constr. rank with ties	constr. rank no ties 1	constr. rank no ties 2	actual rank
constant	1.706	-.50083[b]	-.54302	-.56187	-.42438
	(13.530)[a]	(-2.567)	(-2.417)	(-2.714)	(-2.101)
acres	-00.1344	.00113	.00123	.00132	.000979
	(-4.221)	(3.168)	(2.937)	(3.429)	(2.643)
cost	-.002481	.00313	.00326	.00326	.002172
	(-2.782)	(3.061)	(2.759)	(2.997)	(2.011)
timber	.01193	-.00443	-.00490	-.00489	-.006191
	(3.441)	(-1.045)	(-.965)	(-1.047)	(-1.467)
native	.20063	.36690	.40801	.45107	.32536
	(1.680)	(2.395)	(2.301)	(2.760)	(2.022)
N	1488	1488	1128	1312	1362

[a] (z = $/s.e.)
[b] Rankings are such that a lower number indicates a more preferred option, so it should be noted that the signs on the coefficients are reversed relative to what we usually expect. (For example, the sign we expect on cost is *positive* for the ranking models.)

Table 2 - Results of test of equality of constructed ranks and actual ranks

	Likelihood Ratio[a,b]
actual rank vs. constructed rank - with ties	7.742
actual rank vs. constructed rank - respondents with ties eliminated	6.938
actual rank vs. constructed rank - scenarios with ties eliminated	6.286

[a] distributed ~ P[2]
[b] critical value at "=.05 is 11.0705, at "=.10 is 9.236

Table 3 - Marginal Values and Confidence Intervals

	ratings difference	constr. rank with ties	constr. rank no ties 1	constr. rank no ties 2	actual rank
acres	-0.5417	-0.3604	-0.3791	-0.4057	-0.4507
	[-1.226, -0.312][a]	[-0.730, -0.183]	[-0.868, -0.176]	[-0.838, -0.216]	[-2.089, -0.180]
timber	4.8098	1.4124	1.5041	1.5031	2.8227
	[2.550, 10.761]	[-1.071, 3.871]	[-1.456, 4.588]	[-1.115, 4.250]	[-0.576, 11.764]
native	80.868	-117.0239	-125.3487	-138.5350	-149.7983
	[1.752, 239.8]	[-267.4, -38.0]	[-318.9, -37.4]	[-314.7, -56.3]	[-771.8, -29.8]

[a] [90% confidence interval]

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