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Using Random Parameters to Account for Heterogeneous Preferences in Contingent Valuation of Public Open Space

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To test for preference heterogeneity in dichotomous choice contingent valuation responses, a random parameter logit (RPL) specification is used in this analysis. The RPL model confirms heterogeneity in respondents' preferences for protection of public open space, as reflected in statistically significant standard deviations of the normally distributed random parameters. Results show that while the majority of respondents indicate a positive willingness to pay (WTP), a minority of those surveyed report a negative WTP. Some of this variation in tastes remains even after individual characteristics and attitudinal variables are included in the model.

Key words: contingent valuation, open space, random parameter logit, willingness to pay

Introduction

Throughout the United States there has been a substantial expansion in publicly and privately funded open space preservation programs. These include state government agricultural land preservation programs in 43 of the 48 states in the continental United States and more than a hundred local land trusts. The citizens of Colorado, for example, have dedicated all the proceeds of their state lottery as matching money with county and city governments for acquisition of open space. This collaboration has resulted in 660,000 acres of open space being preserved at an average cost of $13,600 per acre [see Loomis, Rameker, and Seidl (2004) for more information on the Colorado open space program].

In high scenic areas like Aspen, Colorado, and Jackson Hole, Wyoming, there are competing pressures to maintain the open space and scenic vistas that attract people to the area and, at the same time, provide sufficient land for housing development for the workers. Such scenic areas are surrounded by public rather than private land, which intensifies the conflict between those desiring to have some of that land available for housing development and those desiring to retain it as open space in the foreground of

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the public land scenic backdrop. Furthermore, some people view additional government ownership of land—particularly in areas where the government already owns a majority of the land—as constraining individual freedom, and thus oppose it on principle. This conviction characterizes individuals who have been labeled "sagebrush rebels," and refers to those who wish to *reduce* the amount of government ownership of land (Stroup and Baden, 1983; Anderson and Leal, 2001).

Of course, there are often legitimate reasons for public ownership of land to provide natural resource-based public goods (Loomis, 2002). Thus, while a sufficient majority of voters often exist to pass open space funding legislation, there is a diversity of preferences toward government ownership of land as open space. As Bromley (2002) notes, there are changing preferences with regard to what appropriate land uses are. He encourages economists to change their monolithic view of what is economically efficient to reflect this diversity of tastes. This advice is particularly relevant for public programs such as open space preservation that may be viewed by some people positively, as welfare enhancing, and by others negatively, as welfare reducing. Nevertheless, public programs generally have been assumed to be welfare enhancing, which in turn has led to modeling approaches in the contingent valuation literature that usually restrict willingness to pay (WTP) to positive values. Similarly, in modeling attributes, incorporating different tastes and preferences has been limited to including attitudinal variables in the demand or willingness-to-pay function.

In order to address varying individual preferences, an increasing number of research applications have used modeling approaches which explicitly account for zero and negative willingness to pay as well as positive willingness to pay. Among them, Hausman and Wise (1978) explicitly accounted for heterogeneous preferences in the context of a conditional probit model, simultaneously recognizing the interdependence of alternatives. Later, Train (1998) introduced the random parameters or mixed logit model which, building on the framework laid out by Hausman and Wise, provided a richer way to allow for differences in tastes. Specifically, rather than requiring all individuals to have the same values toward different attributes, this model allows the analyst to test whether there exists a statistically significant distribution of the coefficient across individuals in the sample. Most importantly, under certain distributional assumptions for the random parameters such as normality, the sign of the random coefficients will vary from positive for some respondents to negative for others. If this is the case, it illuminates the fact that not only are there varying values, but for some people the public program can represent a public bad, and consequently WTP for those respondents would be negative.

The use of RPL in modeling choice behavior is fairly recent. In the context of valuation of environmental goods, most research corresponds to recreational demand studies and choice experiments. However, little is known about the application of RPL for analyzing discrete choice data from contingent valuation surveys.

In most studies employing the contingent valuation method (CVM), the respondent is required to vote in favor of or against a particular good or program. In the current application, however, we do not model preferences for different programs; rather, preferences are modeled for specific attributes of each program as a repeated decision process. Furthermore, the RPL specification in this survey setting allows us to account for heterogeneity of these preferences beyond what could be explained by individual characteristics of the respondents. The data for this study come from a CVM survey that valued preferences for public retention of different amounts of acreage of public lands administered by the Bureau of Land Management (BLM) along the Snake River in Jackson Hole, Wyoming.

The focus of this study is on testing for the existence of variation among respondents' WTP for the attributes associated with each strategy for managing or disposing of open space, and the impact of heterogeneous preferences on the valuation of these strategies. The nature of the individual variation is also explored—i.e., to what extent heterogeneity arises from observable sociodemographic and attitudinal variables of the respondents or unobservable differences in tastes. In order to test for this individual variation, we include individual variables in interaction with the alternative's amount of acres to be kept in public management, and compare willingness-to-pay estimates produced by the RPL with those of a standard logit model.

The remainder of the paper is organized as follows. The section below gives a review of the current literature on modeling heterogeneous preferences in CVM studies, with particular emphasis on RPL applications. The specific application to open space valuation in Jackson Hole, Wyoming, is then described. Next, the RPL model is specified, and its application to dichotomous choice CVM data is discussed. The main results of the study are then summarized, including a brief benefit-cost comparison. Conclusions are presented in the final section, together with a short discussion highlighting the relevance of our findings for researchers, policy makers, and public land managers.

Previous Studies

Valuation of environmental public goods or services when positive and negative willingness to pay are being observed has been addressed only recently in the literature. Nonetheless, the number of CVM applications dealing with the issue of heterogeneity of preferences both parametrically and nonparametrically has grown rapidly.

Some approaches have addressed the issue by directly eliciting negative WTP using, for example, WTP to avoid the change as a proxy for negative WTP (Clinch and Murphy, 2001). Other studies have used initial attitudinal screening questions to separate respondents by their preferences prior to the valuation question (Kriström, 1997; Huhtala, 2000).

Bohara, Kerkvliet, and Berrens (2001) used Monte Carlo simulation to investigate the performance of different distributions in estimating willingness to pay under three proportions of people holding negative willingness to pay. Clinch and Murphy (2001) valued the increase in Ireland's forest state. They estimated separate and combined models of negative and positive WTP responses using a hurdle specification and concluded that ignoring negative bids results in overestimation of net willingness to pay. With an extended logit model, MacMillan, Duff, and Elston (2001) examined the non-market benefits of the restoration of an area used for grazing of sheep and sport-hunting with two woodland species, the beaver and the wolf.

Huhtala (2000) valued two programs for waste disposal using parametric and nonparametric modeling techniques, and concluded that ignoring heterogeneous preferences led to larger willingness-to-pay estimates, a bias found to be more serious in the parametric estimation. Lockwood, Tracey, and Klomp (1996), also employed parametric and nonparametric methods to estimate willingness to pay for nature conservation and heritage values in conflict with cattle-raising in the Australian Alps.

The use of random parameter models to account for heterogeneous preferences is a fairly new approach in modeling choice behavior, and particularly in stated preference studies. Nonetheless, these models have been used in a variety of applications such as recreational demand and transportation research. In the context of recreational demand, Chen and Cosslett (1998) estimated a random parameter multinomial probit model for recreational fishing trips, accounting for differences in tastes and perceptions of environmental quality across individuals.

Train (1998) estimated an RPL to model anglers' choice of fishing sites. Standard deviations for all the random coefficients were significant, suggesting the parameters indeed varied across the population. Using an RPL specification to determine choice of beaches, McConnell and Tseng (2000) found that some of the random coefficients of the RPL were significantly different from the fixed coefficients of a standard logit. Breffle and Morey (2000) modeled salmon fishing participation and site choice using different model specifications. Their results showed that including heterogeneity yielded larger ranges in expected compensating variation measures.

Stated preference applications of the RPL include Layton (2000); Layton and Brown (2000); and Morey and Rossmann (1999). Using ranking data from a survey of public preferences for hazardous waste cleanup actions, Layton found significant unobserved preference heterogeneity in the rankings. Also, Layton and Brown examined the structure of preferences regarding global climate change with an RPL model, reporting the presence of substantial heterogeneity of preferences in their application. Morey and Rossmann used RPL in a repeated-choice experiment that aimed to estimate benefits from different levels of preservation of marble monuments in Washington, DC.

In addition, RPL has been used in combined revealed and stated preference studies, such as Revelt and Train (1998), who estimated a repeated-choice RPL for households' choice of appliances. The slope coefficients of the RPL were consistently larger than the fixed slope coefficients of a logit model. The standard deviations of the random coefficients were still highly significant after including sociodemographic variables in interaction with price. Based on stated and revealed preference data associated with preferences for automobiles, Brownstone, Bunch, and Train (2000) found the RPL performed better than a multinomial logit model in terms of goodness of fit and revealed a large heterogeneity among respondents for alternative-fuel vehicles.

The current analysis contributes to this literature by exploring the implications of the use of RPL in the analysis of dichotomous choice contingent valuation data in terms of the magnitude of welfare estimates. Although RPL has been applied to modeling stated preferences, its use in the analysis of dichotomous choice data from contingent valuation studies represents an important extension to one of the most widely used stated preference methods in non-market valuation. Unlike other CVM studies that consider heterogeneous preferences for a good or program, this application explores heterogeneity of tastes for the good or program's attributes. As in any other application, the RPL model specification used here was not constrained by the restriction of independence of the different alternatives. Furthermore, it had an inherent flexibility, allowing the different parameters to follow distributions which accounted for both positive and negative domains, or just a one-sided domain. However, this estimation flexibility came at a great cost of computational complexity, imposing strong limitations on the specification of the model.

Application to Open Space Valuation in Jackson Hole, Wyoming

The data used to illustrate the application of the RPL came from a CVM survey designed to quantify economic values of different alternatives for managing 1,600 acres (27 parcels) of federal lands along the Snake River in Jackson Hole, Wyoming. The survey booklet included an introductory section, which described the lands, the issues before the federal land management agency [i.e., the Bureau of Land Management (BLM)], and four possible management strategies for the open space (designated as strategies A, B, C, and D). Respondents were told the survey was being conducted as part of the BLM's Resource Management Plan for the area. The introductory section was followed by a series of attitudinal questions asking the respondents to rate the desirable uses for these 1,600 acres. The core of the survey consisted of three sets of choice questions, where respondents were asked if they would pay for retention and alternative management emphases for different quantities of these public lands. The survey layout and formatting was refined through two focus groups of a random sample of Jackson Hole residents as well as one focus group in Cheyenne, Wyoming, during the first week of June 2000. One-on-one pretests were performed later in June on the complete survey booklet.[1]

While a standard CVM values each program separately, in order to apply RPL we allowed each program to be expressed by different levels of specific attributes—price, amount of acres to be kept in public management, and the level of visitor use allowed. Four management alternatives were developed for the survey. These are: "sale" emphasis (A), "recreation" emphasis (B), "conservation" emphasis (C), and "development" emphasis (D). These alternatives are described more fully below:

- Management alternative A was defined as the sale of all 1,600 acres of public lands to private landowners with the only restriction on use being local zoning. Therefore, the amount of acres of public land attached to this alternative was equal to zero. Under this scenario, development activities would be undertaken, which would reduce the amount and quality of wildlife habitat and restrict some of the existing recreational activities (boat-in camping), although the number of visitors would remain at the actual amount of 30,000 persons.

- Alternative B was to keep 1,400 acres (19 parcels) in public ownership. BLM would develop additional recreation facilities (e.g., boat ramps, campsites) and would undertake management for increased recreation use (up to 50% increase in river rafting use), allowing the number of visitors to increase up to 45,000.

- Alternative C was to keep all 1,600 acres in some form of public ownership and emphasize wildlife habitat management by limiting river recreation (reduce river rafting by 25%). In this case, the number of river visitors would decrease to 22,500.

- Finally, alternative D was to keep 1,400 acres in public ownership and sell up to eight parcels to private landowners, maintaining the number of river visitors at its current level of 30,000 persons.

[1] The survey booklet is available from the corresponding author, John Loomis.

The elicitation question in each of the three choice occasions was worded as follows:

> *"Would your household pay $xx increase in federal income taxes each year for 20 years into a BLM Snake River Management Fund to be used only for managing these lands according to management strategy B (C or D) instead of having BLM sell these public lands (alternative A)?" [Yes] [No]*

The price of each alternative corresponded to the bid amount stated in the question. All respondents faced the same sequence of three binary choices ($t = 3$), and in each of these three choice occasions they chose between two alternatives of management ($j = 2$)—i.e., alternative A versus B (recreation) in the first choice occasion, alternative A versus C (conservation) in the second occasion, and alternative A versus D (development) in the third occasion.

Based on past literature for valuing open space in the intermountain West, input from the focus groups, and pretesting, respondents were asked to pay one of 15 different dollar amounts ranging from $2 to $295 for alternatives B, C, or D. After the valuation question, demographics were collected on each respondent as well as information about their recreational use of the Snake River and frequency of visits.

Specification of the RPL Model

In the specification of the RPL model, each sampled respondent n faces a choice among J alternatives in T choice occasions. The person's utility from choosing alternative j in choice occasion t can be represented as $U_{njt} = \beta_n' x_{njt} + \varepsilon_{njt}$, where ε_{njt} is i.i.d. extreme value over alternatives and independent from β_n and x_{njt}. The coefficient vector β_n is not observable for each individual n and varies over respondents with density $f(\beta_n \mid \theta)$, where θ represents the parameters of this distribution. Since the ε_{njt}'s are extreme value, the probability conditional on β_n that each individual respondent n chooses a given alternative i among the total J alternatives in time t is standard logit (Maddala, 1997; Revelt and Train, 1998):

$$(1)\qquad L_{nit}(\beta_n) = \frac{e^{\beta_n' X_{nit}}}{\sum_j e^{\beta_n' X_{njt}}}.$$

Let i_t represent the alternative chosen by a given respondent n in choice occasion t, such that $i = i_1, \ldots, i_T$ represents the sequence of choices made by the person. Because the ε_{njt}'s are independent over choice situations, the probability of this sequence, conditional on β_n, is the product of the logits:

$$(2)\qquad P(i \mid \beta_n) = L(i_1, 1 \mid \beta_n) * \ldots * L(i_T, T \mid \beta_n).$$

The conditional probabilities are integrated over all possible values of β_n using its density, such that

$$P(i \mid \theta) = \int P(i \mid \beta_n) f(\beta_n \mid \theta)\, d\beta_n,$$

which is called the mixed logit choice probability. The integral in this probability does not have a closed form, and consequently simulation is required. The simulation is performed summing over R draws of β_n taken from its density $f(\beta_n \mid \theta)$ (Revelt and Train, 1998; Train, 1998, 1999; Morey and Rossmann, 1999). The logit formula is calculated for each draw, and the simulated probability is the average of these calculations. The simulated log-likelihood function is created from the simulated probabilities.

As pointed out by Revelt and Train (1998), there are two parameter descriptions in the specification of the RPL model: (*a*) the coefficient vector β_n associated with each person n and representing the individual tastes or preferences, which in turn vary in the population with density $f(\beta_n \mid \theta)$, and (*b*) the parameter θ, which represents the mean and variance of β_n. The analyst's final goal is to estimate θ, the population parameter that reveals the distribution of the individual parameters.

The estimation of the RPL was conducted in panel form (since this is a more efficient estimation procedure) using GAUSS for Windows NT/95, version 3.2. As recommended by Train (1999), Halton draws were used and a total of 125 simulations were conducted to estimate each model.[2]

RPL with Only Choice-Specific Attributes

Two specifications of the RPL model were estimated. The first included only choice-specific attributes, namely the alternatives' price, acres of open space retained, and the number of river recreation visitors allowed. The conditional indirect utility expression for this model is written as follows:

$$V_{njt} = \beta_1 Price + \beta_2 Acres + \beta_3 Recreation + \varepsilon_{njt}, \tag{3}$$

where *Price* is price ($) of the alternative. It equals 0 for alternative A (the default) and it takes on one of fifteen dollar amounts ranging from $2 to $295 for alternatives B, C, and D. *Acres* is the number of acres to be kept as open space by public ownership. It takes on three different values: 0 for option A, 1,400 for alternatives B and D, and 1,600 for alternative C. *Recreation* denotes number of visitors. It takes on three different values: 30,000 for alternatives A and D, 45,000 for alternative B, and 22,500 for alternative C.[3] The performance of this RPL model was contrasted with a standard logit model of homogeneous preferences with only choice-specific attributes and fixed coefficients.

RPL with Choice-Specific Attributes and Demographic Interaction Terms

The second specification of the model included individual characteristics in interaction with the number of acres attached to each management alternative. The conditional indirect utility expression for this model is represented by:

$$V_{njt} = \beta_1 Price + (\beta_2 + \beta_3 Visitor + \beta_4 Income + \beta_5 Wildlife) \times Acres + \beta_6 Recreation + \varepsilon_{njt}, \tag{4}$$

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[2] This code was developed by Kenneth Train, David Revelt, and Paul Ruud at the University of California, Berkeley. We thank Professor Train for his valuable comments and his generosity in making the code available to us.

[3] Variables for quality of wildlife habitat, and alternative specific constants (to reflect other contextual attributes of each alternative) were tried in the RPL model but were insignificant. Therefore they were dropped from the final specification.

where *Visitor* is a dummy variable (1 = visitor, and 0 otherwise); *Income* is the respondent's personal income; and *Wildlife* is an attitudinal variable indicating whether wildlife habitat is a desirable use of the open space, with values ranging from 1 (not desirable use) to 4 (very desirable use). The variable *Acres* was rescaled, dividing it by 100, while the variables *Recreation* and *Income* were divided by 1,000 to facilitate convergence of the model. The interaction variables were not further rescaled.

This model was contrasted with a standard logit where utility is a function of individual characteristics. As noted by Adamowicz, Louviere, and Swait (1998), the classic way to allow for preferences to vary across individuals is to interact personal characteristics with model parameters. Thus, in both the logit and RPL, preferences were allowed to vary according to the visitor status of the respondent, her/his income level, and whether wildlife was a desirable use for open space.

In the RPL, the mean of the random parameters is estimated, together with their variance, while in the standard logit, the variance is set equal to zero.[4] Consequently, the attributes with random coefficients will have a distribution around the mean, which will reveal the existence of preference heterogeneity (Hensher, 2001). Hence, the larger the variance, the more heterogeneity of preferences in the population (McConnell and Tseng, 2000).

Possible Distributions of the Random Coefficients

The random coefficients can be given different distributions such as normal, lognormal, triangular, or uniform. With the normal distribution, some individuals will have negative parameters and others positive parameters, with the proportion of each group empirically determined by the mean and standard deviation of the distribution (Train, 1998, 1999). While the lognormal distribution is useful when the coefficient is known to have the same sign for every person, as a shortcoming, it produces a very thick right tail. The triangular distribution exhibits a peak in the center and drops off linearly on both sides of the center. Unlike the previous two distributions, it is defined by three parameters.

As Hensher (2001) argues, none of the distributions has all the desirable properties, and the selection of one over another is still an area of current research. Although a normal distribution of the random parameters is the most common assumption, in principle any of the distributions expected to fit the estimated parameters can be chosen. Of course, the choice of distribution can be guided by economic theory, since theory will often indicate if a variable can be signed or not.

In the application at hand, we believe the two random coefficients can take on either sign for different individuals in the population. Consequently, we explored distributions of the β_n's that allowed both positive and negative coefficients for a given attribute—

[4] As noted by Chen and Cosslett (1998), in testing the assumption that a fixed parameter model is the proper modeling framework, we must test that each variance of each random parameter associated with each individual in the sample is equal to zero. To guarantee the inequality constraint that each individual variance of the random parameter (s_n^2) is greater than or equal to zero (nonnegative), we must impose extra restrictions on the likelihood estimator. In order to do so, an asymptotic simulation of the distribution of the likelihood-ratio test must be performed. However, in our particular case study, because of the small data set and the limited range of values of some of the variables, convergence of the algorithm is infeasible when simulating the asymptotic distribution of the likelihood-ratio test. The requirement for extremely high data quality is not often met in most empirical studies; consequently, this test is infrequently carried out in the applied literature. Nonetheless, this test should be performed when the researcher has a large data set, and one that has a choice set design closer to a full factorial which would make this test feasible.

namely the normal distribution. Both specifications of the RPL were estimated with price and the interaction terms fixed and letting the coefficients on acres of open space and recreation be random [i.e., β_2 and β_3 in equation (3), and β_2 and β_6 in equation (4)].

WTP Calculations

With the price coefficient fixed, WTP followed the same distribution as the attribute's coefficient, and it was calculated as the ratio between the mean of the random parameter of the particular attribute and the price coefficient. Specifically, for the model in equation (3), willingness to pay was calculated as $WTP_{Acres} = \beta_2/\beta_1$ and $WTP_{Recreation} = \beta_3/\beta_1$ for both the logit and RPL models. The standard deviation of WTP was calculated as the ratio between the standard deviation coefficient of the random parameters and the price coefficient (Revelt and Train, 1998).

For the specification in equation (4) with interaction terms, mean WTP for the RPL was calculated as:

$$(5) \qquad Mean\ WTP_{Acres} = \frac{\beta_2 + \left[\dfrac{\sum_n \beta_3 Visitor_n + \sum_n \beta_4 Income_n + \sum_n \beta_5 Wildlife_n}{N}\right]}{\beta_1},$$

where n indicates each individual, and N is the sample size. In order to consider the nature of the random parameter, we first simulated the individual betas (the normal random parameter) drawing randomly generated numbers from a normal distribution with the mean and standard deviation of β_2. WTP was then predicted for each individual according to her/his visitor status, income, and preferences for wildlife according to equation (5).

Results

The 12-page survey booklet was mailed to 800 randomly selected Jackson Hole residents along with a \$1 incentive on the first mailing. A significant number of addresses were undeliverable ($n = 165$), and four people were deceased, reducing our net sample size to 631. After two mailings, the response rate for the net sample of local residents was 59%, or 372 returned surveys. Of these, 308 respondents provided complete surveys for all the variables included in the model (attributes and personal characteristics). Since each respondent faced three choice questions where she/he valued different open space management alternatives with different attribute levels, the total number of observations was 924 (308 × 3).

When asked to choose the most preferred management alternative at no cost, most respondents selected management alternative C (conservation), which enhanced wildlife protection at the expense of a 25% reduction in recreational use (i.e., from 30,000 to 22,500 visitors). Management alternative B (recreation), which increased recreational use from 30,000 to 45,000 visitors, was the second most preferred alternative. These results are reported in table 1.

The survey included a series of attitudinal questions regarding the most preferred uses for the open space, which shed some light on different preferences for the attributes attached to each management alternative. Thus, averaged across the sample, the most

Table 1. Management Alternative Preferences (sample size = 308)

Management Alternative	Percentage of Respondents Selecting Alternative as Their Preferred	Management Alternative	Percentage of Respondents Selecting Alternative as Their Preferred
Sale (A)	2.4%	Conservation (C)	54.8%
Recreation (B)	25.4%	Development (D)	17.4%
	Total = 100%		

Table 2. Distributions of "Yes" Responses over Programs and Bid Amounts

		MANAGEMENT ALTERNATIVES					
		A vs. B		A vs. C		A vs. D	
Alternative's Price ($)	Total Responses	"Yes" Responses	% of Total	"Yes" Responses	% of Total	"Yes" Responses	% of Total
2	18	16	88	14	78	11	61
3	18	16	88	14	78	10	55
5	25	18	72	18	72	17	68
7	24	18	75	19	79	17	70
10	24	17	71	21	87	11	46
15	20	18	90	15	75	10	50
20	20	14	70	13	65	11	55
30	23	11	48	14	61	10	43
40	23	12	52	14	61	12	52
50	16	10	63	12	75	5	31
70	21	12	57	11	52	9	42
90	18	13	72	12	67	9	44
125	18	11	61	10	56	9	50
175	19	9	47	13	68	3	16
295	21	7	33	10	47	6	28
	Total = 308						

desirable uses of the BLM-administered public lands were bird nesting habitat, other wildlife habitat, fish habitat, non-motorized recreation, and open space. On average, the least desirable uses identified by respondents were houses, grazing, motorized recreation, and sand/gravel mining. The question is whether these averages mask significant preference heterogeneity in the population. Therefore, we also analyzed the distribution of positive responses to each program broken down by each price or bid level. These results are presented in table 2. The general trend of the declining percentages of "yes" responses at higher bid amounts was apparent, although given the small number of responses at each bid, it is not surprising that the function was not monotonic throughout. The means and standard deviations of the explanatory variables are provided in table 3.

RPL with Only Choice-Specific Attributes

Table 4 reports the estimates of the RPL as compared to the standard logit including only choice-specific attributes—i.e., the number of *Acres* of open space and the number

Table 3. Summary Statistics of Relevant Variables

Variable	Mean	Std. Dev.	Variable	Mean	Std. Dev.
Price ($)	60.36	79.23	*Ac_Vis (Acres*Visitor)*	13.23	4.44
Acres (100s acres)	14.66	0.94	*Ac_Inc (Acres*Income)*	1,370.53	828.75
Recreation (1,000s visitors)	32.50	9.35	*Ac_Wild (Acres*Wildlife)*	54.40	10.46
Visitor (dummy 0, 1)	0.90	0.29			
Income ($1,000s)	93.54	56.07			
Wildlife (categorical, 1 to 4)	3.69	0.70			

Table 4. Logit and RPL Model Estimates (sample size = 924)

Variable / Description	Parameter	Logit	RPL
Price	Mean of Fixed Coefficient	-0.0051***	-0.0102***
		(0.0009)	(0.0024)
Acres	Mean of Normal Coefficient	0.0504***	0.0997***
		(0.0060)	(0.0171)
	Standard Deviation of Normal Coefficient	—	0.1781***
			(0.0187)
Recreation	Mean of Normal Coefficient	0.0050	0.0068
		(0.0073)	(0.0102)
	Standard Deviation of Normal Coefficient	—	0.0026
			(0.0174)
Mean Log Likelihood		-0.6503	-0.5567
LRI/Pseudo-R^2		0.68	0.73
WTP ($/100 acres)	Mean	$9.88	$9.77
	Standard Deviation	—	$17.46

Notes: Asterisks (***) denote statistical significance at the 1% level. Values in parentheses are standard errors. LRI denotes Likelihood-Ratio Index.

of visitors allowed (*Recreation*) under each management alternative. In the logit model, the coefficients on *Price* and *Acres* were significant at conventional levels and had the expected signs, while the coefficient on allowable *Recreation* use was not significant. Not unexpectedly, the fixed coefficients of the logit model were consistently smaller than those for the RPL, a result which has been well documented in other applications (Revelt and Train, 1998).

In the RPL, the estimated mean coefficient on *Acres* was positive and statistically significant. The standard deviation was also highly significant, implying that preferences indeed varied in the population for this attribute. The RPL model provided a better fit to the data than the standard logit model, although the difference between the likelihood-ratio indices was not large.

The normal distribution allowed coefficients of both signs, with the proportion of each group determined by the mean and standard deviation of the distribution of the random parameter (Train, 1998, 1999). Thus, for *Acres*, the RPL model showed that 29% of the respondents had a negative coefficient for this attribute. As evidenced by this negative coefficient, "more conservation" is not always viewed as good by everyone in a particular population. The mean coefficient on *Recreation* and its standard deviation were insignificant.

For both the RPL and the logit model, willingness to pay for each attribute was calculated as the ratio of the attribute's coefficient over the price coefficient. The mean WTP estimates were very close in magnitude for both models. For the logit model the average respondent was willing to pay $9.88 for 100 extra acres of open space, while for the RPL, mean WTP was $9.77 (table 4). However, these similar mean WTP values could mask the underlying heterogeneity in preferences regarding *Acres*.

The results from the RPL imply that WTP for a 100-acre increase in public land kept as open space was normally distributed with mean $9.77, and the standard deviation of WTP is $17.46 (= 0.1781/0.0102). This large standard deviation represents an important variation in WTP in the population. With a fixed-price coefficient, WTP follows the distribution of the random parameter; thus the 29% of people having a negative coefficient for this attribute is consistent with 29% of the survey respondents reporting negative WTP for an increase in open space in Jackson Hole. Since the parameters associated with *Recreation* use were not significant, we did not calculate WTP for this attribute.

RPL with Choice-Specific Attributes and Demographic Interaction Terms

Although the estimates in table 4 indicate the parameters indeed varied in the population and therefore preferences were heterogeneous, we did not assess to what extent this variation could be explained by individual characteristics of the respondents. The nature of this variation was captured by interaction terms between individual characteristics of the respondent and choice-specific attributes. Table 5 presents the results for the model with interaction terms specified in equation (4) and normally distributed random parameters. The variable *Ac_Vis* corresponded to the interaction between the number of acres attached to the management alternative and the dummy variable *Visitor*, which indicated whether the respondent was a visitor to the area. The variable *Ac_Wild* was the interaction between *Acres* and the attitudinal variable *Wildlife*, which ranked from 1 to 4, with a value of 1 indicating wildlife habitat was the least desirable use for the open space. Finally, the variable *Ac_Inc* was the interaction between *Acres* and the personal *Income* of the respondent.

The inclusion of these cross-products allowed us to account for the fact that people with different visitor status, attitudes toward wildlife preservation, and income levels may have different marginal utilities with respect to the program at hand. Hence, in this RPL specification, WTP for the attributes was expected to vary depending on (*a*) whether the respondent was a visitor to the area, (*b*) the respondent's income level, and (*c*) the respondent's most desirable use for the public lands. As noted by Breffle and Morey (2000), the interaction between choice-specific attributes and attitudinal variables allows the analyst to consider the different types of individuals in the sample. Thus, the way participants differ in terms of socioeconomic variables and how they respond to attitudinal questions may provide insight as to whether preferences should be expected to vary across individuals.

An examination of table 5 for the standard logit model reveals the coefficients on *Price*, *Acres*, and each of the interaction terms were highly significant at conventional levels, while the coefficient on *Recreation* was not statistically significant. As in the previous results (table 4), the fixed coefficients of the logit were consistently smaller than the RPL coefficients. The values of the log-likelihood functions and the likelihood-ratio

Table 5. Logit and RPL Model Estimates with Interaction Terms of Individual Characteristics and Acres (sample size = 924)

Variable / Description	Parameter	Logit	RPL
Price	Mean of Fixed Coefficient	-0.0061*** (0.0009)	-0.0113*** (0.0023)
Acres	Mean of Normal Coefficient	-0.2135*** (0.0349)	-0.3491*** (0.0810)
	Standard Deviation of Normal Coefficient	—	0.1610*** (0.0178)
Recreation	Mean of Normal Coefficient	0.0055 (0.0076)	0.0072 (0.0101)
	Standard Deviation of Normal Coefficient	—	0.0001 (0.0177)
Ac_Vis (*Acres*∗*Visitor*)	Mean of Fixed Coefficient	0.0434*** (0.0161)	0.0871*** (0.0420)
Ac_Inc (*Acres*∗*Income*)	Mean of Fixed Coefficient	0.0003*** (0.0001)	0.0005*** (0.0002)
Ac_Wild (*Acres*∗*Wildlife*)	Mean of Fixed Coefficient	0.0544*** (0.0083)	0.0880*** (0.0185)
Mean Log Likelihood		-0.6098	-0.5371
LRI/Pseudo-R^2		0.70	0.74
WTP ($/100 acres)	Mean	$9.03	$9.61
	Standard Deviation	—	$36.39

Notes: Asterisks (***) denote statistical significance at the 1% level. Values in parentheses are standard errors. LRI denotes Likelihood-Ratio Index.

indices indicate that the models with interaction terms yielded a slightly better fit than similar models without interaction terms presented in table 4. As pointed out by a reviewer, the RPL without interaction terms (table 4) had a better fit than the standard logit model with demographic interaction terms (table 5).

In the RPL (table 5), the fixed coefficient on *Price* and the interaction variables *Ac_Vis* (acres and visitor status), *Ac_Inc* (acres and income), and *Ac_Wild* (acres and wildlife) were statistically significant at conventional levels. The mean coefficient on *Acres* was significant at the 1% level, and also its standard deviation estimate was large and significant, suggesting WTP for this attribute varied beyond what could be explained by the visitor status of the respondents, their attitudes toward open space, and their income. In contrast, the mean and standard deviation coefficients on *Recreation* were small and not statistically different from zero.

While the sign on the *Acres* coefficient changed from positive in the models with only choice-specific attributes to negative when individual variables were interacted with *Acres* in both the logit and RPL models, the positive signs on the interaction terms swamp this negative sign. Specifically, WTP for additional acres of open space increased with the level of income, when the respondent was a visitor to the area, and when she/he placed a high importance on wildlife habitat as a use for the acres of open space. Thus, the value for an increase in open space was positive over a large portion of the respondents, but not the entire sample.

WTP for 100 acres of additional open space at the mean values of *Visitor*, *Income*, and *Wildlife* was equal to $9.03 for the logit model. This value will indeed be larger for higher income categories and for those respondents who see wildlife management as a more desirable use for the open space.

In turn, results for the RPL showed that WTP for 100 acres of land being kept in public management was normally distributed with a mean equal to \$9.61 and standard deviation equal to \$36.39. This result implies that about 39% of the people in the sample had a negative WTP for this attribute once individual characteristics were considered. The smallest WTP value for this sample was -\$130, which corresponded with individuals from the lowest income categories, who were not visitors, and for whom wildlife management was not a desirable use. On the positive side of the distribution, the highest WTP value was \$113 for those people with high income levels, who were visitors to the area, and who preferred wildlife management over other uses.

As in the previous model without interaction terms, the goodness-of-fit measures suggest the RPL provided a better fit to the data compared to the logit model. In turn, both models performed slightly better than the equivalent models without interaction terms presented in table 4.

Once again, the similarity of means obtained from both models masks the underlying heterogeneity of preferences. Even after adjusting for observable demographics and tastes, we found a statistically significant standard deviation on *Acres*, indicating some unobserved preference heterogeneity for acres of open space remained in our sample responses. This translates into more than one-third of Jackson Hole residents having negative WTP for additional acres of open space.

Overall, our findings suggest that although mean WTP was not sensitive to different modeling specifications, there was a distribution of WTP among the sample. While the normality assumption for the random parameters implies some proportion of the sample will necessarily have a negative coefficient and some proportion will have a positive coefficient, the exact fraction with each sign is determined empirically from the data. The reason for this preference heterogeneity toward open space may be that in an area such as Jackson Hole with very little private land and very high housing costs, some county residents prefer the public land be made available for development, while more environmentally inclined individuals may prefer protection of open space. Thus, the issue of positive and negative attitudes toward the resource may be ideally tested using the RPL specification. This preference heterogeneity is further confirmed by the fact that the coefficient on *Acres* continued to range from positive to negative even when individual characteristics of the respondents were included in the model.

To briefly address the economic efficiency of retaining these 1,600 acres of public open space along the Snake River, we compare our survey WTP results to the opportunity costs. Given the average RPL WTP estimate of \$9.70 per 100 acres, and 7,300 households in Teton County, the annual value is \$1.13 million for retention of the 1,600 acres. Using a 6% interest rate, this gives a present value of \$18.9 million. Finding the market value of the undeveloped BLM parcels is difficult because there are not perfectly comparable land sales. The average farmland values in the area are roughly \$800 an acre, while developed riverfront acreages average nearly \$300,000 an acre. While Teton County residents' WTP easily exceeds average farmland values, their WTP values do not exceed riverfront land values. However, coupling Teton County residents' WTP with the WTP of a separate sample of Wyoming residents (Loomis, 2001) suggests the benefits of this open space retention would be approximately equal to even the higher opportunity costs.

Conclusions

The use of random parameter logit has become a popular approach in modeling choice behavior. Unlike conventional logit models, it has the advantage of capturing much broader substitution patterns among choice alternatives. RPL has been used in a variety of applications, such as recreational demand and transportation research, as well as in commodity demand studies using stated and revealed preference approaches, but little is known about its application in modeling dichotomous choice contingent valuation data.

In this analysis, the RPL was applied to model heterogeneous preferences for alternative management of open space. The RPL was compared against a logit model. We included three choice-specific attributes (acres in open space, recreation use levels, and price of the alternative), together with individual characteristics and attitudes of the respondents to account for respondents' preferences. The RPL yielded consistently larger coefficient estimates for all variables than the standard logit—a finding that has been documented by previous studies (see Revelt and Train, 1998). While the marginal WTP for an increase in acres of open space was almost identical in the logit and RPL with and without individual demographics, our results confirmed the existence of heterogeneity in respondents' preferences for acres of open space. This was reflected in significant standard deviations of the coefficients in both RPL model specifications. Heterogeneity remained even after individual characteristics were included in interaction with acres.

The RPL with only choice-specific attributes revealed that an important percentage of the sample (29%) had a negative coefficient on acres of open space, and consequently a negative WTP for an increase in this attribute. Moreover, when individual variables were included, the RPL showed an even higher proportion of the respondents (39%) had negative WTP for more acres of open space.

Our results suggest that if heterogeneous preferences for a public program are believed to exist, researchers should test for these preferences using the RPL framework rather than modeling techniques which disregard the possibility that preferences indeed vary over people. If the standard deviations of the variables are significant and span the positive and negative portions of the real number line, then the good in question generates contrasting preferences, and the random parameter specification is more likely to be a proper approach. In this case, a standard logit model can falsely conclude that a particular attribute is not statistically significant due to a large variance on the fixed coefficient. However, it might be that the attribute in question does matter—but positively for some people and negatively for others. This information on the variation in tastes and valuation can be relevant to policy makers and public land managers who must balance welfare of diverse publics, rather than manage for the average person when making decisions.

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