A Hierarchical Bayes Approach to Modeling Choice Data: A Study of Wetland Restoration Programs

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Abstract

This study examines the factors the influence the values and importance that landowners place on the attributes of voluntary wetland restoration programs. Choice-based conjoint analysis, a stated preference method, was used to estimate the marginal utilities and values for restoration program attributes for North Carolina landowners. Landowner preferences were estimated at individual and aggregate levels to examine the importance of modeling heterogeneous preferences. Choice modeling performed at both aggregate and individual levels demonstrated the information gains from a disaggregated approach.

Key words: landowner decision-making, program participation, conjoint analysis, heterogeneous preferences, conservation

Introduction

Wetland policy in the US has undergone a dramatic shift within the last few decades. Between roughly 1850 and 1970, public policies aided in the draining and conversion of wetlands to other uses, reflecting public opinion that these areas were seen as having little to no productive value in their natural state. Wetlands were commonly seen as undeveloped agricultural resources, since they provided rich, productive soil when drained (Lewis, 2001). During this period, over two thirds of the original wetlands in the continental United States were drained or converted to other uses (Heimlich, et al. 1998).

Wetland policies began to shift in the 70's and 80's with the scientific community's gradual discovery of the important environmental and ecological services these areas provide (Lewis, 2001). Among these services are water filtration, drought and flood mitigation, provision of habitat for plants and animals, and erosion control along shorelines (Richardson, et al. 1985; van Vuuren and Roy, 1993; Mitsch, et al. 1995). With these discoveries, the emphasis of wetland policy shifted from aiding in destruction and conversion to rigorous attempts to preserve the remaining wetlands and to bring "prior-converted wetlands" (wetlands that had previously been drained or filled) back to their natural state. Caught in the middle of these changing policies are the individual landowners. Since nearly 80% of the remaining wetlands are on privately held land (Heimlich, 1998), preservation of these resources is dependent on the decisions of private landowners that hold the ownership rights.

Current wetland policies include not only programs to protect remaining wetlands, but also programs to make restoring prior-converted wetlands an economically viable option for landowners (Heimlich, et al. 1998). In response to wetland restoration objectives, several programs have been developed that offer landowners a chance to receive payments for restoring prior-converted wetlands back to a natural state. These voluntary programs are offered by a variety of agencies in different governmental sectors, and they differ in other aspects regarding their administration, regulations and payment structures. A crucial, but understudied, aspect of wetland restoration programs is how the options provided by these programs influence the participation decisions of eligible landowners (Cubbage and Flather, 1993). Understanding how these landowners view the program benefits and weigh them against the costs of program participation can improve the operation of public policies aimed at encouraging wetland restoration.

Objectives

The main objective of this article is to gain a better understanding of the decision-making process of landowners in regards to their participation in wetland restoration programs. Using data collected from agricultural landowners, we used choice-based conjoint analysis, a stated preference methodology, to estimate the value and importance that landowners place on the various design aspects of wetland restoration programs. These results were then used to show how landowner preferences influence choices among competing wetland restoration programs.

The application of conjoint analysis involves asking respondents, in a survey setting, to rank, rate or choose their preferred option among a set of goods that are described to respondents as having differing levels of provision of a set of component attributes. The result is estimation of partworths, or marginal utilities, for the attributes that comprise the good (Louviere, et al. 2000). The researcher's choice of a ranking, rating, or choice-based format is usually determined by the specifics of the issue being studied. A choice-based format has emerged as the most common application, since it often most closely mirrors the format in which respondents actually make decisions (McCullough, 2002). One disadvantage of this format, however, is that standard estimation methods only allow for modeling at the aggregate level (Holmes and Adamowicz, 2002).

An implicit assumption in aggregate-level models is that of homogeneity of parameters, with the parameters representing the average value for the population. The possibility of heterogeneous preferences among the population is ignored in aggregate-level models. Recent innovations in discrete choice modeling, however, have allowed for disaggregate, or individual-level, models to be estimated from choice-based conjoint analysis (Andrews, et al. 2002; Ter Hofstede, 2002; Train, 2002). These individual-level models result in a much finer precision on the individual values than is possible with aggregate-level models. A second objective of this article is thus to model landowner preferences at the individual level to examine the role of heterogeneity in these preferences and to demonstrate the importance of accounting for it. This article compares results obtained under assumptions of homogeneous and heterogeneous preferences to show potential advantages to be gained from the modeling of heterogeneity.

Methods

This study is based on results of a public opinion survey of landowners. Aspects of the data collection process are described in this section, followed by discussions of the methodology used to estimate individual-level parameters and the choice modeling done with these parameters.

Data collection

This study utilized an existing data set collected through a survey of 510 landowners in selected areas of North Carolina (Kramer, et al. 2004). The survey was designed with the assistance of agricultural and wetland experts and based on information obtained from a series of focus groups conducted with landowners. Survey data collection occurred in winter 2000/2001. A combined mail/telephone format was used for the survey, where respondents were mailed supplemental information, but all questions were answered by phone. The respondents were paid $25 for completing the survey, which had an adjusted response rate of 75%.

As part of the choice-based conjoint analysis method, respondents were provided with a series of ten choice tasks involving comparisons of wetland restoration programs with varying levels of attributes. Each choice task displayed three potential wetland restoration programs, from which respondents selected their preferred alternative. The programs were described to respondents as a set of six attributes (program payment, program administration, recreational use, contract type, timber harvesting options and contract length). Through the survey design phase, this list of attributes was determined to be the most important factors influencing program participation choices. Survey respondents were then shown a series of choice tasks and asked to select their preferred choice among the three restoration programs listed in each choice task.

The attribute levels for the programs in each choice task were varied according to an experimental design (Holmes and Adamowicz, 2002). This design resulted in a set of 100 unique choice tasks, with each respondent completing a subset of 10 of these choice tasks. Following each choice task, respondents were asked a follow-up question that enabled them to opt out of the market if they would not actually participate in their preferred program choice. Descriptions of the attributes and their corresponding levels of provision are presented in Appendix 1, and a sample choice task from the survey is presented in Appendix 2. The survey instrument is available from the authors upon request.

Estimation of individual-level parameters

The common conceptual framework for choice-based conjoint is the utility-theoretic approach of discrete choice models, which posits that individuals, when faced with a choice among competing alternatives, attempt to maximize their utility by making the choice thought to provide the highest utility (Adomowicz et al., 1997; Adomowicz et al., 1998). Assuming that the unobserved portions of utility are distributed IID Type 1 Extreme Value yields the common conditional logit specification (Train, 2002). The probability that individual n would choose alternative i out of set of j alternatives is given by:

$$P_{ni} = \frac{e^{b'X_{ni}}}{\sum_j e^{b'X_{nj}}}$$

which is the utility of alterative i divided by the utility of all alternatives in the choice set. In this specification, X_{ni} denotes the attributes of alternative i and individual n, and β denotes the partworth utilities for these attributes. The parameter values of interest are generally estimated through maximum likelihood methods (McFadden, 1974; Adamowicz, et al. 1994).

One drawback of this framework is that only aggregate-level models can be estimated and the partworth values are assumed to be homogeneous for all members of the population (McCullough, 2002). If a significant amount of heterogeneity exists in the population, more accurate information would be obtained from explicit modeling of this heterogeneity. One approach for capturing this heterogeneity is to estimate a disaggregate model.

Recent developments in discrete choice modeling have enabled the estimation of disaggregate, or individual-level, parameters from choice-based conjoint analysis (McFadden and Train, 2000; Allenby and Rossi, 2003). One possibility involves assuming that the partworths, instead of being fixed in the population, vary according to some known probability distribution, the parameters of which can be estimated. For example, if a normal distribution for the parameters is assumed, the mean of this distribution measures the average value for the population and the standard deviation measures the degree of heterogeneity present within the population for that parameter. This assumption yields a random effects, or heterogeneous logit, model that describes how the parameter values vary in the population without actually estimating these individual values (Arora, et al., 1998). The random effects model can be specified as follows:

$$P_{ni} = \frac{e^{b_n' X_{ni}}}{\sum_j e^{b_n' X_{nj}}}$$

which is similar to the specification for the conditional logit model with the additional assumption that the parameters vary across individuals instead of being fixed in the population.

To gain additional information, individual-level parameters can also be estimated directly. From the perspective of classical statistics, mixed coefficient models have been developed that involve combining maximum likelihood estimates of the population distribution with the choices made by individuals in the sample (Revelt and Train, 1999;

Train, 2002). Additionally, from a Bayesian perspective, hierarchical modeling can be used to link information about the distribution of coefficients across the sample with information about the choices made by individuals to obtain estimates of individual values (Allenby and Rossi, 2003). Despite the different theoretical frameworks of these two perspectives, it is important to note their numerical relationship. Estimates of the same model obtained from these two methods converge asymptotically, and the differences between them thus relate more to the interpretation of the results than the results themselves (Huber and Train, 2001; Train, 2002).

In this study, the hierarchical Bayes (HB) method is used to estimate individual-level parameters from the choice-based conjoint analysis data. With Bayes' Theorem, initial estimates of probabilities can be revised using information provided by the data to obtain a posterior probability estimation that utilizes both initial information and information from the data (Winkler, 2003). This concept is the foundation for the modeling done with HB, and is what enables individual-level parameters to be derived from each individual's information combined with information from the complete sample of individuals.

The HB method involves combining aggregate and individual-level specification of parameters. At the aggregate level, the random effects specification is used to allow for parameters that vary across individuals according to a normal distribution. At the individual level, a standard multinomial logit specification is assumed for the probability of each individual's choice among alternatives. The parameters to be estimated in the HB method are β, α and D, with β_n representing a vector of partworths for the n^{th} individual, α representing a vector of means of the distributions of individuals' partworths, and D representing a variance/covariance matrix of the distribution of individual partworths. The HB method uses an iterative procedure to estimate these values, where one parameter is being estimated conditional on the current values for the other two parameters. This process, known as Gibbs sampling, is typically run for thousands of iterations. To derive the final individual partworth estimates, the last several thousand iterations are saved and the parameter estimates from these iterations are averaged (Train, 2002).

Choice modeling

Within the marketing tradition, results from conjoint analysis studies are commonly used in market simulation models (Green, et al. 2001; Deal, 2003). These simulations take the relatively abstract partworth utilities and turn them into information more useful and understandable from a managerial perspective. Methods used to translate partworth utilities into predicted respondent choices are known as choice models (Arenoe, 2003). With market simulations, the performance of competing alternatives can be evaluated.

When individual-level data are available, the most common choice model, known as First Choice (FC), is consistent with a utility maximization framework. The model involves summing the partworth utilities for each respondent for each alternative under consideration and assuming that respondents choose the alternative with the highest utility. The percentage of times each alternative is chosen is then calculated and expressed as how often that alternative would be chosen, assuming respondents had to choose an alternative in the set (Orme, 2002). When individual-level data are not available, a Share of Preference (SP) model can be used on the aggregate-level data. As with the FC model, the SP model involves summing the utilities for each alternative. The utilities are the exponentiated and then converted to percentages that sum to 100. One drawback of the SP model is that it is susceptible to the independence of irrelevant alternatives (IIA) property, which is commonly associated with the aggregate logit model (Orme, 2003).

Results and Discussion

This section presents the estimated partworths and uses them to explore the values and importance that landowners place on the various attributes of wetland restoration programs. These results are then used in choice models to show landowner preferences among sets of competing wetland restoration programs. Results from modeling at both an aggregate and disaggregate scale are used to provide some understanding of the importance of incorporating heterogeneity.

Estimation of partworth utilities

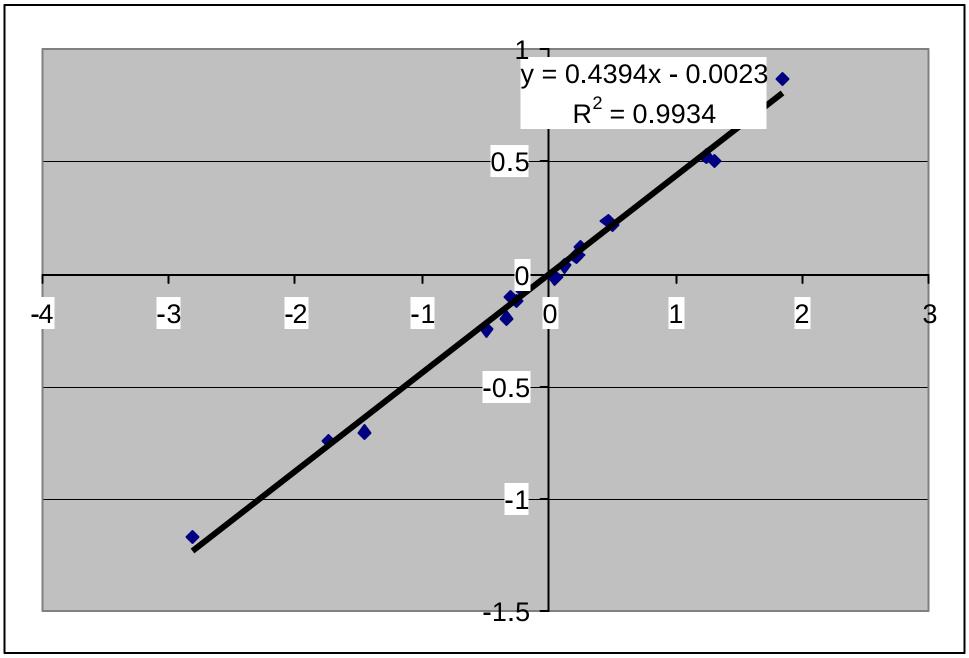
The primary output of conjoint analysis is the estimated partworths for the levels of the various attributes. Table 1 presents these partworth values estimated at both the aggregate level with a multinomial logit model and at the individual level with the HB method. Although the various attribute levels are coded as dummy variables, we used an effects coding procedure, which constrains the sum of partworth values to be zero instead of setting one level to zero as in traditionally done in the analysis of dummy variables (Holmes and Adamowicz, 2002). Additionally, figure 1 presents the results of a regression of the HB partworths on the aggregate multinomial logit model partworths.

As indicated by the regression, there is very high level of correlation between the estimates with $r^2 = .99$. Despite the similarity of the results obtained by these two methods, the HB results provide a much greater level of detail than the aggregate model since the HB method estimates the distribution of individuals and the partworths of each individual.

Table 1. Partworth Estimates for the Sample (HB and Multinomial Logit Models)

Attribute Level	Partworths – HB Model (95% credible interval)	Partworths – Multinomial Logit Model (t statistic range)
Contract length		
10 years	1.845 (1.695 – 1.995)	0.866 (NA)
15 years	1.304 (1.223 – 1.385)	0.505 (5.068 – 16.028)
30 years	-0.340 (-0.430 – -0.250)	-0.198 (-1.873 – -5.922)
Permanent	-2.809 (-2.964 – -2.653)	-1.173 (-6.452 – -20.404)
Timber harvesting options		
No harvesting allowed	-1.740 (-1.815 – -1.665)	-0.742 (-6.395 – -20.222)
Selective thinning only	0.505 (0.453 – 0.558)	0.218 (NA)
Harvesting allowed	1.235 (1.150 – 1.320)	0.524 (7.002 – 22.142)
Price per acre		
$75	-1.456 (-1.538 – -1.374)	-0.705 (NA)
$125	-0.489 (-0.522 – -0.456)	-0.248 (2.463 – 7.782)
$175	0.466 (0.427 – 0.504)	0.235 (4.059 – 12.825)
$225	1.479 (1.389 – 1.569)	0.719 (4.832 – 15.269)
Program administration		
Federal	-0.301 (-0.361 – -0.241)	-0.100 (-1.143 – 3.616)
State	0.222 (0.182 – 0.262)	0.081 (0.964 – 3.049)
Combined State/federal	-0.049 (-0.090 – -0.008)	-0.018 (-0.647 – -0.205)
NGO	0.128 (0.046 – 0.210)	0.037 (NA)
Contract type		
Restoration contract	0.252 (0.186-0.318)	0.119 (NA)
Conservation easement	-0.252 (-0.318 – -0.186)	-0.119 (-1.944 – -6.149)
Recreational use		
By landowner only	-0.214 (-0.250 – -0.177)	-0.078 (NA)
May be leased	0.214 (0.177 – 0.250)	0.078 (1.642 – 5.191)

Figure 1. HB versus Aggregate Logit Partworth Estimates



Both the HB and multinomial logit models indicated a high level of statistical significance for the attribute levels, with all levels having the expected signs. For the HB results, a 95% credible interval is reported under each parameter estimate. A credible interval is the Bayesian equivalent to a classical confidence interval, but differs slightly in its interpretation. The credible interval identifies the range in which there is a 95% probability that the true parameter value falls (Winkler, 2003). For all of the parameters estimated from the HB model, a zero value fell outside of this 95% credible interval, indicating that all independent variables have an influence on the dependent variable at the 95% level.

For the multinomial logit model a range for the t statistic is reported. Since each respondent performed 10 choice tasks, the t statistics as they are reported in the regression output are inflated. Each of these t statistics was divided by the square root of the number of choice tasks performed by the respondent to correct for this inflation (Holmes and Adamowicz, 2002). Thus, the range is a lower bound and upper bound on the t statistic. At the upper bound t statistic, all attribute levels are highly significant with the exception of the "combined state/federal" level of the program administration attribute. At the lower bound t statistic, none of the levels for program administration were significant, but all other levels were significant at the 90% level, with most being significant at the 95% or 99% levels.

An additional "goodness of fit" measure used with the HB method, called percent certainty, calculates how much better the derived model fits the data than a model chosen at random. This is calculated by subtracting the log likelihood of a chance model from the log likelihood of the final model. This measure is then normalized between zero and one by dividing this difference by the negative of the log likelihood of the chance model. The percent certainty from the HB method indicates that the log likelihood for this model is 58.2% better than that of a model estimated at random (Sawtooth Software, 1999).

Estimation of Marginal Values

Partworths are commonly converted to marginal values for welfare economic evaluations. Dividing the coefficients of levels for the various attributes by the marginal utility of money yields an estimate of the marginal value of the attribute levels. The marginal value of money was calculated as the change in the coefficient for each level of the payment attribute divided by the change in the dollar amount for that level. One critical assumption of using the marginal utility of money for welfare calculations is that the marginal utility of money is constant, meaning that the gain in utility from an additional dollar is the same across the range of possible changes in the respondent's income (Train, 2002). For the landowner data, the marginal utility of money was constant to three decimal places across the different payment levels, with an average value of 0.0194. Using this value, the marginal values for the levels of the different attributes are presented in table 2. For each attribute level, the marginal value represents the payment at which the respondent would be indifferent between that additional payment and receiving that particular level of the attribute, with other attributes being held constant.

Table 2. Marginal Values

Attribute Level	Partworths – HB model	Marginal Value
Program Payment		
Payment Value	0.0194	$1.00
Contract length		
10 years	1.845	$95.10
15 years	1.304	$67.22
30 years	-0.340	-$17.53
Permanent	-2.809	-$144.79
Timber harvesting options		
No harvesting allowed	-1.740	-$89.69
Selective thinning only	0.505	$26.03
Harvesting allowed	1.235	$63.66
Program administration		
Federal	-0.301	-$15.52
State	0.222	$11.44
Combined State/Federal	0.049	$2.53
NGO	0.128	$6.60
Contract type		
Restoration contract	0.252	$12.99
Conservation easement	-0.252	-$12.99
Recreational use		
By landowner only	-0.214	-$11.03
May be leased	0.214	$11.03

The marginal values for the various attributes provide information on how program payments would need to be set to entice enrollment for programs with different mixes of attributes. For example, with all other attributes held equal, a program that currently allowed timber harvesting could pay $37.63 less per acre than a program that only allowed selective thinning, and $153.35 less than a program that did not allow any timber harvesting. Information on the marginal values of the different program attributes can thus assist program managers in weighing the costs and benefits of providing different attributes in their programs.

Importance scores

When individual-level parameters are available, researchers commonly calculate the importance of the various attributes (Green, et al. 2001; Ofek and Srinivasan, 2002). This importance measure is calculated by constructing a ratio with the numerator equaling the difference of the maximum value for the levels of a particular attribute and the minimum value for the levels of that same attribute. The denominator of the ratio is the sum of the values obtained in the numerator for all the attributes, which normalizes the scores to sum to 100%. The importance scores are presented in table 3.

Table 3. Importance Scores For Wetland Restoration Program Attributes

Attribute	Score (0 – 100%)
Contract length	33.6%
Timber harvesting options	21.8%
Price per acre	21.1%
Administration	10.8%
Contract type	7.8%
Recreational use	4.9%

The importance scores yielded some interesting information about the factors that drive landowner decision-making. With the two most important attributes being the contract length and the timber harvesting options, it is clear that issues of control are important to landowners when making program participation decisions. These two attributes most severely restrict the landowners' ability to use their land as they desire. For the contract length attribute, landowners may not be willing to enter into an agreement that would tie up their land for too long of a period of time. The importance placed on timber harvesting options is understandable since this is one of the biggest income generating activities in which landowners can engage. Restriction on this activity can thus have serious financial implications, and also represents an area of their farming operations over which they may wish to maintain control. While the price per acre attribute also has financial implications, it is possible that timber harvesting was more important since it represents a way that landowners can make money from their own activities. As several landowners expressed in the focus groups conducted during the survey design phase, money made from their own activities may give them more utility than money given to them for participating in a program.

Several different reasons could explain why some attributes received low importance scores. After the price attribute, the next most important attribute was the administration of the program. While this attribute does not relate as directly to control issues or financial incentives, there is clearly some level of importance attached to this attribute. Given the number of negative comments about the federal government that were voiced during the focus groups, this result was not surprising. Some landowners clearly had strong feelings about entering into agreements with the federal government, due to a lack or trust or a variety of other reasons. This attribute also could have been viewed as important due to the respondents' feelings about state government, or the possibility of working with a non-governmental agency.

The contract type attribute relates directly to control issues, since it determines whether the respondent could break their commitment with the program and prematurely terminate their contract. It is thus surprising that this attribute received a relatively low importance score if issues of control are indeed important to landowners. One possible explanation is that, despite a detailed explanation of the attribute in the survey materials, the respondents may not have understood this attribute and its possible ramifications. Another possible explanation is that the respondents may have thought there were some negative consequences associated with early termination of a program and did not view this as a viable option.

The recreational use attribute had the lowest importance score. Although this attribute does influence a landowner's ability to control how their land is used, it does not exert much of an influence. Since, at both possible levels of this attribute, the landowner can use the land themselves, this attribute would not hold much importance for people that are not interested in leasing their land for recreation. Additionally, even if people are interested in leasing their land, the returns from this activity are low compared to other attributes that affect financial returns (price per acre, timber harvesting options). It is logical, then, that the recreational use attribute would have a lower importance score than these other attributes.

Comparison of heterogeneous logit and hierarchical Bayes partworths

As discussed above, there are two main approaches to estimating individual-level parameters. One step is to adopt a heterogeneous logit approach, where estimates of a mean and standard deviation of parameters are used to make assumptions about the distribution of parameters within a population. A more comprehensive approach is to actually estimate the individual-level parameters. Figures 2 and 3 present estimates of the individual-level partworths for the "permanent" level of the contract length attribute using these two different approaches. Figure 2 uses the heterogeneous logit approach, where estimates of the mean and standard deviation are used to define the normal distribution under which the parameters are expected to fall. These estimates were taken from the HB method and used to describe the distribution of the partworths without actually estimating the individual values. Figure 3 shows a histogram of the partworths as estimated by the HB method. Comparisons of the two figures show the additional information that can be gained from the estimation of individual values. While the values estimated by the HB method can be roughly approximated by a normal distribution, this approximation would loose information regarding the non-normality of the distribution of these values. Constraining these values to a normal distribution would only capture a portion of the heterogeneity that actually exists in the population, and the assumption of a normal distribution would misrepresent this heterogeneity.

Figure 2. Estimation of the Permanent Contract Length Attribute Level by Heterogeneous Logit

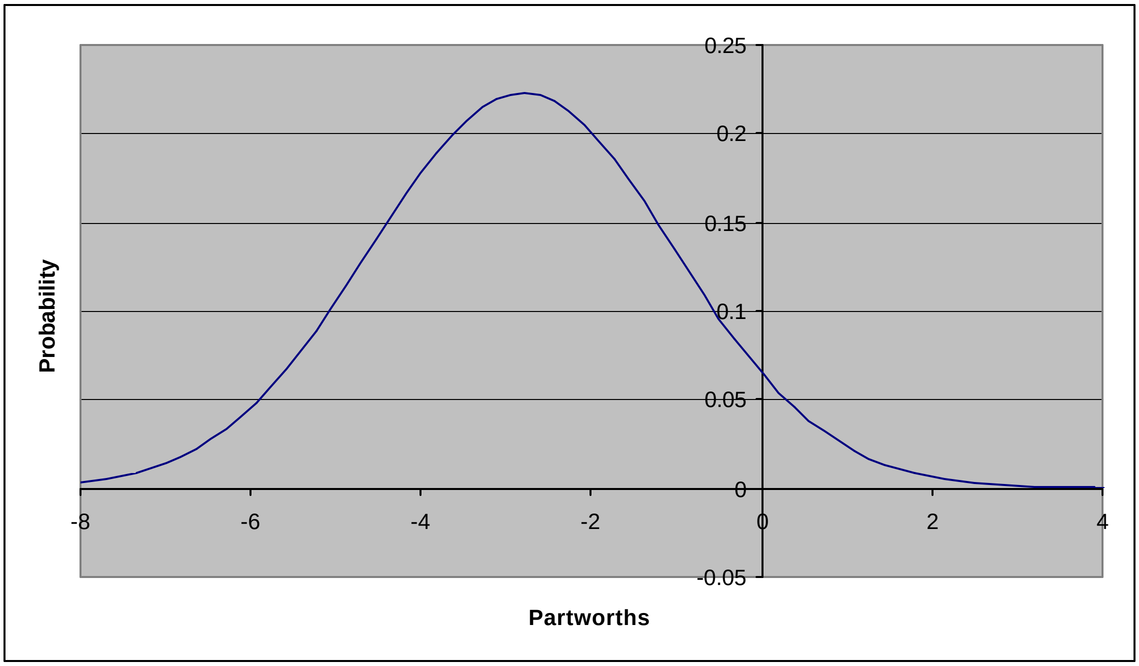
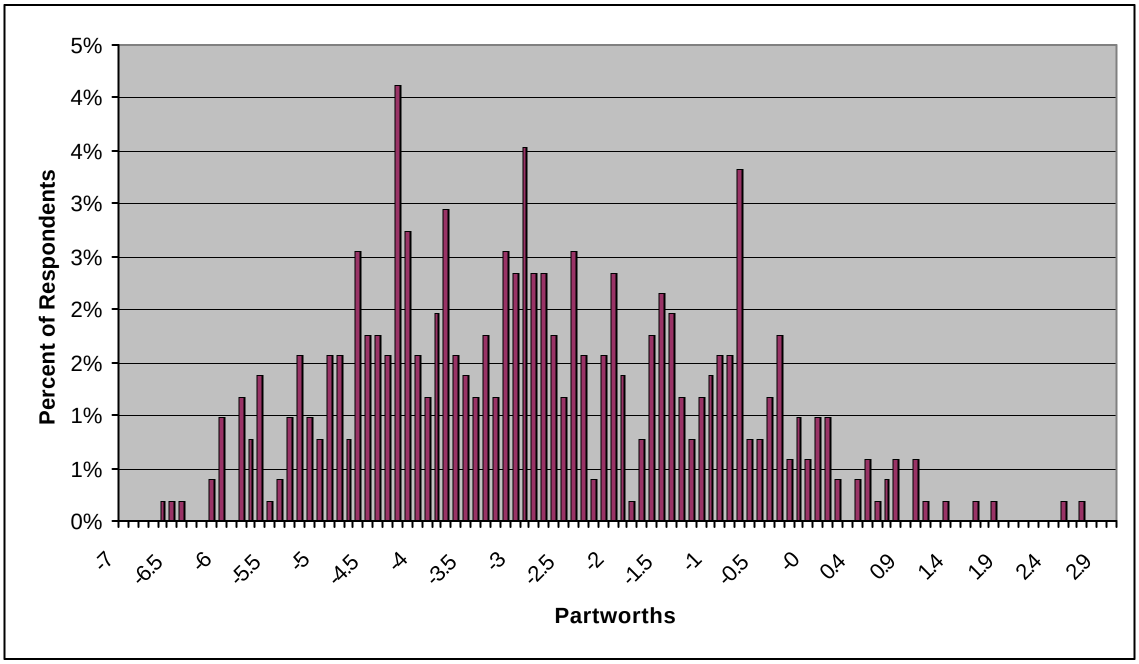


Figure 3. Estimation of the Permanent Contract Length Attribute Level by the Hierarchical Bayes Method



Choice modeling

In addition to examining the importance of the various wetland restoration program attributes, the partworth values were used in choice modeling to understand how different programs perform in terms of landowner preferences. Additionally, in order to examine how assumptions of heterogeneity might influence these results, choice modeling was performed using the aggregate multinomial logit results, the heterogeneous logit results, and the individual parameters from the HB method. The Share of Preference model was used for the aggregate multinomial logit results. Preference shares for the heterogeneous logit and the HB results were obtained from the First Choice model. As mentioned above, this model can only be estimated with individual-level data. Since the heterogeneous logit approach does not actually estimate individual-level parameters, a process called sample enumeration was used to approximate individual level data (Train, 2002). This process involves, for each of the partworths, taking random draws from the distribution given by the heterogeneous logit model to obtain a set of individual values that follow the distribution. For example, since the landowner data set contained 510 observations, 510 random draws from each partworth distribution were taken for the sample enumeration process.

Table 4 presents results from a choice modeling scenario with three competing wetland restoration programs. The three programs in this scenario are similar on some attributes, but differ in contract length, program administration and payment. table 4 first presents the levels of the various attributes for three programs, and then the choice modeling results for the aggregate logit model, heterogeneous logit model and the HB model. These results show that Program 3 is largely preferred by landowners, which follows from its offering of the most preferred payment level of the three programs and also from it being tied with Program 2 for offering the most preferred level for contract length among the three programs.

Table 4. Choice Modeling Scenario #1

Program Options	Program #1	Program #2	Program #3
Contract Length	Permanent	30 years	30 years
Contract Type	Conservation easement	Conservation easement	Conservation easement
Program Administration	State agency	Federal agency	Combination of state and federal agencies
Recreational Use of Enrolled Land	May be leased or used by landowner	May be leased or used by landowner	May be leased or used by landowner
Timber Harvesting Options	Selective thinning allowed	Selective thinning allowed	Selective thinning allowed
Program Payment	$125 per acre per year for 50 years	$125 per acre per year for 30 years	$175 per acre per year for 30 years
Preference Share (Aggregate logit)	**3%**	**22%**	**75%**
Preference Share (Heterogeneous logit)	**7%**	**16%**	**77%**
Preference Share (Hierarchical Bayes)	**3%**	**10%**	**87%**

Comparisons of the three different kinds of choice modeling emphasize how the incorporation of heterogeneity influenced the results. Moving from the aggregate choice model to the one based on the HB results, the preference share of Program 2 decreased and the preference share for Program 3 increased. Using the aggregate logit or heterogeneous logit results would thus misrepresent the actual respondent preferences. However, the ranking of programs was consistent across the model results.

A second choice modeling scenario is shown in table 5. In contrast to the previous scenario, table 5 presents a scenario in which the three programs are fairly different from each other, and the programs are more balanced in their offerings of more and less preferred attribute levels. Programs 1 and 3, for example, have the less preferred contract lengths, but have more preferred timber harvesting and program payment levels than Program 2. Additionally, while Program 3 has the least preferred program administration level, it has the most preferred levels for the enrollment options and timber harvesting attributes.

Table 5. Choice modeling scenario #2

Program Options	Program #1	Program #2	Program #3
Contract Length	Permanent	15 years	Permanent
Contract Type	Conservation easement	Conservation easement	Restoration contract
Program Administration	State agency	Non-Governmental Agency	Federal agency
Recreational use of Enrolled Land	May be leased or used by landowner	May used by landowner only	May be leased or used by landowner
Timber Harvesting Options	Selective thinning allowed	No harvesting Allowed	Harvesting allowed
Program payment	$125 per acre per year for 50 years	$75 per acre per year for 15 years	$125 per acre per year for 30 years
Preference Share (Aggregate logit)	**22%**	**32%**	**45%**
Preference Share (Heterogeneous logit)	**15%**	**37%**	**47%**
Preference Share (Hierarchical Bayes)	**21%**	**39%**	**40%**

The results for this scenario again show differences between the three choice models. From the aggregate and heterogeneous logit results, Program 3 is the preferred choice, but results from the HB model indicate that Programs 2 and 3 are roughly equal in their preference share. While both Programs 1 and 3 have a permanent contract length, Program 1 has less preferred options than Program 3 on several of the other attributes, and is thus dominated by Program 3 in all the choice models. Program 1 has a more preferred program administration level than Program 3, but this is outweighed by the other attributes for which Program 3 has a better level than Program 1. As with the first choice modeling scenario, landowner preferences are misrepresented when they are not actually modeled at the individual level.

Conclusion

Understanding how the design aspects of wetland programs influence landowner preferences can increase the effectiveness and efficiency of these programs. This article addresses these issues through modeling preferences at both aggregate and individual scales. Estimation of marginal utilities and values showed how the different program attributes affected the utility of the respondents, and the payments that would be necessary to keep them indifferent between different levels of attribute provision. Importance score results indicated that, while program payment was an important factor in enrollment decisions, options such as the contract length and timber harvesting options were the primary drivers of landowner decision-making in relation to these programs.

By modeling preferences at individual and aggregate scales, this article showed that additional information could be gained from incorporating assumptions of heterogeneous preferences and estimating these preferences at the individual level. Partworth values from both individual and aggregate models had the same signs, but the individual-level values were larger, reflecting the increased information gained from the individual-level modeling. Through choice modeling scenarios, this article also showed that different results were obtained from using partworths estimated at different scales, underlying the importance of explicit modeling of heterogeneity when it exists in the population.

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Appendix 1 – Description of Wetland Restoration Program Attributes

This appendix presents selected text from a booklet entitled "Wetlands and the Private Landowner." Survey respondents were sent this booklet along with the survey materials and were asked to read it before they were interviewed.

How wetland programs work

Wetland programs are voluntary and give landowners the opportunity to receive payments for restoring and protecting wetlands on their property. The programs also pay the costs of the wetland restoration activities. Interested landowners can sign up for these programs at any time. Program staff work with the landowner to develop plans for undertaking wetland restoration on their property. As described below, these programs offer several different options for landowners.

<u>Contract type:</u>

Wetland programs offer two different enrollment options. In both of these options, the landowner maintains control of the access rights to their land:

- Restoration contract

In a restoration contract, the landowner enters into an agreement with the program to restore a previously converted wetland area. The landowner agrees to restrict their productive use of the enrolled land in exchange for payments from the program. This contract is between the program and the landowner and does not transfer with the property if it changes ownership for any reason. Participants may transfer the contract to new owners, or request early termination. Some funds may have to be returned to the sponsoring agency in the case of an early termination.

- Conservation easement

With a conservation easement, the deed of the property is amended to limit the future productive uses of the enrolled land. The easement remains in effect for a specified period and transfers to the new landowner if the land changes ownership for any reason. With a conservation easement, it is not possible to request an early termination, or to change the agreement on sale of the property.

<u>Contract lengths:</u>

These programs offer landowners several different options for the length of time that land can be enrolled in them. These different time options are:

- 10 years
- 15 years
- 30 years
- Permanently

Program administration options:

The agency administering the program enrolls the land, works with landowners and distributes the payments to participating landowners. Programs are administered by one of the following:

- Federal agencies (e.g. US Department of Agriculture)
- State agencies (e.g. NC Department of Environment and Natural Resources)
- Combination of state and federal agencies
- Non-governmental agencies (e.g. Nature Conservancy, Ducks Unlimited)

Recreational use of enrolled land:

Landowners may use enrolled land for undeveloped recreation such as hunting and fishing. Some programs may also permit the landowner to lease the enrolled land to other people for undeveloped recreation. The possibilities for recreational use of enrolled land are:

- May be used by the landowner only
- May be leased or used by the landowner

Timber harvest options for enrolled land:

Wetland programs may allow landowners to harvest timber on enrolled land. The timber harvest options are as follows:

- No timber harvesting allowed

One option is that the landowner would not be allowed to harvest any timber from enrolled lands.

- Selective thinning of timber allowed

Another option is that the landowners could use enrolled lands for selective thinning of timber. In selective thinning, only the largest, dominant trees are removed. This stimulates the growth of smaller trees and/or tree species that are favored for timber production or improved wildlife habitat. Selective thinning practices would be subject to regulations designed to protect the environmental benefits of the enrolled lands. For instance, no thinning would be allowed within 50 feet on either side of streams.

- Harvesting allowed

Another option is that landowners could harvest timber on enrolled lands. Timber harvesting would be subject to regulations designed to protect the environmental benefits of the enrolled lands. These regulations would include the use of 50-foot buffer zones on each side of streams that would be free of any logging activity. Additional regulations would also include some restrictions on the use of landings, roads and skid trails.

Program payment:

Landowners would receive a rental payment for enrolling land into these programs. This payment is in addition to the amount paid by the programs to cover the out of pocket costs associated with restoration activities.

Appendix 2 – Sample Choice-Based Conjoint Analysis Choice Task

1. Please look at the following three wetland restoration programs. PLEASE ASSUME THAT THESE ARE THE ONLY THREE CHOICES AVAILABLE TO YOU AND DO NOT ALSO CONSIDER PROGRAMS LISTED ON OTHER PAGES. Although you may not be interested in any program, if these programs were the ONLY choices available to you, which one would you prefer?

Program Options	**Program #1**	**Program #2**	**Program #3**
Contract Length	10 years	30 years	15 years
Contract Type	Conservation easement	Restoration contract	Restoration contract
Program Administration	Non-governmental agency	Combination of state and federal agencies	Federal agency
Recreational Use of Enrolled Land	May be used by landowner only	May be used by landowner only	May be leased or used by landowner
Timber Harvesting Options	Selective thinning allowed	No harvesting allowed	Harvesting allowed
Program Payment	$75 per acre per year for 10 years ($750 in total)	$225 per acre per year for 30 years ($6,750 in total)	$75 per acre per year for 15 years ($1,125 in total)

Please mark which program you would prefer _____ _____ _____

Note: After respondents answered this question, they were asked if they would actually participate in the program they chose, if it were offered to them.