Use of Dichotomous Choice Nonmarket Methods to Value the Whooping Crane Resource

J. M. Bowker and John R. Stoll

A dichotomous choice form of contingent valuation is applied to quantify individuals' economic surplus associated with preservation of the whooping crane resource. Specific issues and limitations of the empirical approach are discussed. The results of this case study reveal that models with similar statistical fits can lead to very disparate measures of economic value, regardless of whether the mean or median is chosen to estimate average willingness to pay. Such results suggest caution is necessary when applying dichotomous choice models in contingent valuation.

Key words: dichotomous choice, logit, probit, truncation, willingness-to-pay.

Market prices for endangered wildlife species rarely exist. When prices do exist, they are not likely to reflect accurately individual preferences. Both consumptive uses, such as hunting, fishing, and trapping (Boyle and Bishop 1985; Stoll and Johnson; Brookshire, Eubanks, and Randall) and more esoteric benefits, such as viewing and existence values must be considered. This article is addressed to the valuation of whooping cranes (*Grus Americana*), a prominent endangered species.

The purpose of this article is to present a methodology for estimating nonconsumptive benefits associated with the existence of an endangered species. A dichotomous choice form of contingent valuation is applied to quantify individuals' economic surplus associated with preservation of the whooping crane resource. Specific issues and limitations of the empirical approach are discussed, some of which have been previously examined by Bishop and Heberlein (1979) and Hanemann.

The present paper expands upon earlier work in several ways. First, in addition to discussing the above issues, a unique application of the approach to an endangered species is presented. Second, three model specifications are examined, two of which are consistent with utility theory and one which is not (Hanemann). Third, again following Hanemann, economic surplus is estimated at the sample median as well as the mean. The discussion of the last two issues sheds light on their implications for estimation of economic surplus.

Throughout the article, the suitability of alternative estimation techniques for dichotomous choice (or referendum style) data is examined. The methodological and empirical results are relevant to a number of current issues regarding model specification, choice of binary response model, and choice of estimator for equivalent surplus (Hanemann; Boyle and Bishop 1984; Sellar, Chavas, and Stoll).

Whooping Crane Resource

The whooping crane is classified as endangered under the federal Endangered Species Program (Stoll and Johnson). Whooping cranes have been close to extinction since 1941, when their numbers were estimated to be fifteen birds. In 1987, the entire population of whooping cranes was believed to be about

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168 birds, of which 109 birds comprised the only wild breeding flock in the world (Aransas National Wildlife Refuge, personal communication, 22 May 1987). This flock migrates between Wood Buffalo National Park in Canada and Aransas National Wildlife Refuge in Texas. Thirty-four additional birds are located at Patuxent Wildlife Research Center in Maryland, the International Crane Foundation Research Center in Wisconsin, and the San Antonio Zoo. An experimental sandhill crane foster parent flock of approximately 22–25 birds, which is dispersed and hard to count, also migrates between Idaho and New Mexico (Aransas; Stoll and Johnson).

Public interest in whooping cranes is evidenced in a number of ways. The U.S. Fish and Wildlife Service maintains research and breeding programs, a Whooping Crane Conservation Association has been founded, and a $7.5 million trust fund has been established to protect land along the cranes' migratory path. Additionally, of the 60,000 to 100,000 visitors to the Aransas National Wildlife Refuge annually, most come during the whooping cranes' wintering period (Stoll and Johnson).

Concepts of Value

To better understand valuation of nonmarket resources such as endangered species, the various use and nonuse components of total value for wildlife resources must be considered. A number of economists have recently contributed to identifying and defining components of total resource value (Boyle and Bishop 1985; Bishop and Heberlein 1980; Randall and Stoll 1983; Bishop; Walsh, Loomis, and Gillman). In the case of endangered species, nonuse values are likely to dominate the total value. There is virtually no "consumptive use" value for whooping cranes. Individual values associated with "nonconsumptive use" are probably higher than "nonuse values," but there are many more nonusers than users. Consequently, values of nonusers constitute the major component of benefits derived from the species. Such nonuse benefits fit the description of public goods.[1] Their omission would understate total resource value and lead to underprovision or less support for provision than is socially warranted.

The Dichotomous Choice Form of Contingent Valuation

A number of nonmarket methods are available to estimate the total value of whooping cranes. These include the travel cost method (Gum and Martin), simulated market method (Bishop and Heberlein 1979, 1980; Bishop et al.), and contingent valuation method (CVM) (Boyle and Bishop 1984, 1985; Sellar, Stoll, and Chavas). Many researchers have applied and compared nonmarket valuation methods for different goods (Bishop and Heberlein 1979, 1980; Sellar, Stoll, and Chavas; Boyle and Bishop 1984; Stoll, Smathers, and Shulstad). Cummings, Brookshire, and Schulze have summarized this literature.

A CVM approach was chosen to estimate values for the whooping crane resource. While some have cast doubts on the efficacy of using CVM to elicit economic values (Rolston; Samples, Gowen, and Dixon), the travel cost and simulated market methods are inappropriate when nonuse values are important. At present, there is no consensus about the preferred form of contingent valuation for valuing endangered wildlife species. In this study, a closed-end dichotomous choice approach is selected.

The use of dichotomous choice (DC) techniques for CVM involves creation of hypothetical environments which include an artificial market mechanism. For the whooping crane study, subjects were informed that a policy change could lead to cessation of public funding necessary to support the continued existence of the whooping crane species (see appendix). They were then asked to accept or reject an offer to contribute annually to a trust fund that would be used to ensure the continued existence of the species. Each subject responded to one offer which was randomly selected from a preselected range. The results of the responses from all subjects were subsequently analyzed using appropriate binary response statistical models to determine the expected value which respondents place on the resource.

The dichotomous choice approach has been used by other researchers (Boyle and Bishop 1984, 1985; Sellar, Stoll, and Chavas) since

[1] Nonuse clearly fits the traditional description of a public good, while nonconsumptive use more nearly approximates a congestible public good due to location-specific use and associated capacity constraints.'

first being adapted to nonmarket valuation issues by Bishop and Heberlein (1979, 1980). It is simple to administer because no interviewer is required. Respondents are not faced with intricate bidding schemes; moreover, respondents do not have to contemplate exact values for resources for which payment is not customary. They simply respond "yes" or "no" to a single dollar offer. Additionally, the dichotomous choice approach allows for analysis which is consistent with utility theory (Hanemann).

The DC approach also has weaknesses. Qualitative responses mean that less information is elicited from each respondent than may be possible. More sophisticated estimation techniques are necessary to analyze the qualitative responses. Appropriate ranges of value (to set question offer levels) for the good in question must also be predetermined. Finally, as with other forms of contingent valuation, various forms of theoretical bias occur (Cummings, Brookshire, and Schulze; Hoehn and Kreiger). In the DC case, strategic bias and self-selection bias could influence the response, but interviewer bias and starting point bias common to iterative bidding are eliminated.

Model Development

Hanemann has provided the theoretical model from which Hicksian compensating and equivalent surplus measures are obtained from dichotomous choice, discrete response data. In this case Hanemann's model is followed in a willingness-to-pay framework to obtain a measure of individual equivalent surplus. Individual respondents are assumed to know their utility functions which have as arguments income (M), a state of nature with or without whooping cranes (W), and a socioeconomic conditioning factor (S). Other arguments such as prices, which do not change, are suppressed for simplicity. Since there are unobservable random components to an individual's utility function, utility is treated as a random variable with a parametric probability distribution having mean $V(W, M; S)$, and stochastic component e_w, which is an independent and identically distributed random variable with zero mean.

When the individual is confronted with the loss of whooping cranes ($W = 0$) and an amount A which he could contribute to a preservation trust to ensure the species' continued existence ($W = 1$), he will pay the amount only if

$$(1)\quad V(1, M - A; S) + e_1 \geq V(0, M; S) + e_0.$$

The willingness to pay probability can be written

$$(2)\qquad P_1 = F_\eta(dV),$$

where dV is the difference $V(1, M - A; S) - V(0, M; S)$ and F_η is the probability function for the error. If the argument dV is a utility difference, then the binary response model is interpreted as the outcome of a utility-maximizing choice (Hanemann).

Hanemann has suggested explicit specification of the nonrandom component of the indirect utility functions,

$$(3a)\quad V(W, M; S) = a_w + B_1M, \quad W = 0, 1;$$

$$(4a)\quad V(W, M; S) = a_w + B_1\log M, \quad W = 0, 1.$$

These result in utility differences

$$(3b)\quad dV = (a_1 - a_0) - B_1A$$

$$(4b)\quad dV = (a_1 - a_0) + B_1\log(1 - A/M).$$

Others (Bishop and Heberlein 1979, 1980; Boyle and Bishop 1984; Sellar, Stoll, and Chavas; Loehman and De) have not directly specified the utility functions but have specified logarithmic forms as first-order approximations for dV, sometimes including an income term,

$$(5)\quad dV = a_1 + B_1\log A + B_2\log M + a_2S,$$

which may be interpreted as an approximation of a utility difference (Hanemann). While Hanemann's specifications have theoretical merit, Boyle and Bishop (1984, 1985) as well as Sellar, Chavas, and Stoll have found that logarithmic specifications outperform the alternatives posed by Hanemann, based on goodness-of-fit statistics.

In the present willingness-to-pay application, $F_\eta(dV(A))$ represents the probability that an individual will respond positively to paying a specified amount A for the whooping crane resource. The offer, A, is an argument of the utility difference. For a respondent to be willing to pay, his true equivalent surplus (E) must be greater than A. Hence, $F_\eta(dV(A))$ is the same as the probability ($A \leq E$).

Following Hanemann and assuming that the equivalent surplus is random with a probability distribution $G_E(A)$, an estimate of equiv-

alent surplus is obtained by using the expected value of E, E_{MN}, where

$$E_{MN} = \int_0^\infty F_\eta(dV(A))dA. \tag{6}$$

Alternatively, an approximation of equivalent surplus may be obtained by using the median value, E_{MD}, of the distribution $G_E(A)$, where

$$F_\eta(E_{MD}) = .5. \tag{7}$$

Use of the median is argued to be statistically preferred but, from an economic theory standpoint, represents a value judgment (Hanemann, p. 337).[2] Estimating the parametric probability function $F_\eta(dV(A))$ allows us to obtain estimates of the desired welfare measure.

Binary Response Estimation

The estimation procedure involves estimating parameters which define the willingness-to-pay probability function. Applicable qualitative response models include the linear probability model (LPM), the logit model (LM), and the probit model (PM) (Amemiya, Judge et al., Maddala, Pindyck and Rubinfeld, Capps and Kramer). Because of problems with heteroskedasticity (Maddala, p. 16) and the possibility of probability predictions outside the zero to one range (Pindyck and Rubinfeld, p. 241), the LPM model is rarely employed in economic research.

An alternative is to employ a transformation approach. In this case, an index variable $Z_i = X_iB$, representing the utility difference discussed earlier, is employed. Larger Z_i, are associated with greater probabilities that the event (Y_i) takes place, i.e., $Y_i = 1$; hence, there is a monotonic relationship between the probability of the event taking place and the index variable. Under such an assumption the true probability function would resemble a distribution function. The two distribution functions most often selected for use in economic applications are the normal and the logistic, resulting in the probit and logit models.

The argument for adopting the normal distribution function is based on assuming that the individual chooses between a positive and negative response based on comparing Z_i to some critical value of a random index Z^*, which depends on individual tastes. If many independent factors determine the critical level for each individual Z^* may be assumed to be a normally distributed random variable by invoking the central limit theorem (Judge et al., p. 591). However, in many applications the standard logistic distribution function,

$$(1 + \exp(-X_iB))^{-1}, \tag{8}$$

is assumed for F_η. The logistic distribution closely approximates the normal and is numerically simpler (Judge et al., p. 591; Capps and Kramer; Pindyck and Rubinfeld, p. 248). Both the logit and probit models are used in this study.

The parameters for the binary response models may be estimated using generalized least squares (Bishop and Heberlein 1979, 1980; Pindyck and Rubinfeld, p. 250) or maximum likelihood methods (Capps and Kramer; Hanemann; Sellar, Stoll, and Chavas). For experiments with many observations per cell (i.e., many individuals receiving the same offer, having the same income, and having identical socioeconomic characteristics), either method of estimation is acceptable. With few observations per cell, maximum likelihood methods are preferred (Amemiya, Capps and Kramer). In this study maximum likelihood estimation is used. The large sample properties of the ML estimator allow hypothesis testing of linear restrictions by the use of asymptotic t-values as well as either the Wald test or likelihood ratio test (Amemiya).

A number of criteria complementing economic theory have been developed to assist in model selection (Amemiya, Capps and Kramer). In this study we employ (*a*) parameter values, signs, and asymptotic test statistics and (*b*) summary statistics for goodness of fit to the sample data, such as the McFadden R-square (MRSQ), Akaike information criterion (AIC), and the percentage of correct predictions (Amemiya).

Three different specifications for the index variable $Z_i = X_iB$ are employed (equations 3b, 4b, 5). Each specification is estimated in both logit and probit models. In addition to income (M) and offer (A) variables, a socioeconomic binary variable (D_1) is included for membership in one or more wildlife organizations. Such a variable is included to account for indi-

[2] Use of the median could ignore that small proportion of the citizenry who legitimately value the good highly. This arbitrary choice is akin to throwing out outliers which are not in fact outliers, a procedure which would lead to undervaluation of the item being considered. A reviewer noted that "there is no theoretical justification for using medians," and their use "disenfranchises those who have the largest stake in the resource."

viduals likely to have strong feelings in favor of preserving wildlife and as an indicator of wildlife knowledge. An additional binary variable (D_2) is included to account for differences between sample observations obtained at Aransas National Wildlife Refuge and those administered to a random sample by mail.[3] The former respondents were known to have exposure to the whooping crane resource (different household technology, e.g., see Randall and Stoll 1983) and were expected to place a higher value on its preservation. Equations (3b), (4b), and (5) become

$$(9) \quad dV = a_0 + B_1A + a_1D_1 + a_2D_2,$$

$$(10) \quad dV = a_0 + B_1\log(1 - (A/M)) + a_1D_1 + a_2D_2, \text{ and}$$

$$(11) \quad dV = a_0 + B_1\log A + B_2\log M + a_1D_1 + a_2D_2,$$

where a_0 is interpreted as $(a_1 - a_0)$ in utility difference terms for equations (9) and (10) but not as a utility difference for equation (11).

Application to the Whooping Crane Resource

The survey was administered in the winter/spring of 1983 to (*a*) users of the Aransas National Wildlife Refuge and (*b*) nonusers of the refuge, including Texas residents and residents of four standard metropolitan statistical areas (i.e., Los Angeles, Chicago, Atlanta, and New York).

The mail and on-site surveys were carefully designed, reproduced in booklet form, and pretested according to accepted standards (Dillman). The on-site questionnaire was given to 800 visitors at the refuge on eleven different weekday and weekend dates. A total of 1,200 were mailed to Texas residents and 600 questionnaires were divided among the four large SMSA's. Response rates were 67% for on-site subjects and 36% for mail administration. Information collected from respondents included socioeconomic characteristics and value responses to the contingent market scenario. Of the 1,031 returned questionnaires, 290 were not usable for this part of the analysis because of various omissions, leaving a sample size of 741.

[3] Survey instruments were identical except for the removal of four pages dealing with on-site activities when administered by mail. On-site respondents were handed the instrument and asked to complete it with no assistance to simulate the manner in which mail respondents would receive the instrument.

Empirical Results

The ML estimates of the three specifications [equations (9), (10), and (11)] for the logit and probit models are shown in table 1. The signs of all coefficients conform to prior expectations. In all specifications the binary variables representing wildlife club membership and site specificity are highly significant. The logit and probit models differed little in terms of summary statistics and parameter significance for any given specification of the utility difference. This corresponds with prior work in which neither model dominated the other empirically in the binary dependent variable case (Capps and Kramer).

The estimation revealed considerable differences regarding the three specifications for underlying utility differences. Based on the scalar criteria reported in table 1, specifications (9) and (10) proposed by Hanemann are inferior to the logarithmic specification (11). The McFadden R-squares for both the logit and probit logarithmic models are 40% or more higher than for the two specifications offered by Hanemann. Similar differences appear among the model chi-square statistics resulting from the likelihood ratio test of the null hypothesis that all nonintercept parameters are zero. The AIC statistics, which can be used for testing non-nested models (Amemiya, p. 1505), are consistent with these results. The percentage of correct predictions for various models was close, but the logarithmic model was superior, correctly predicting 78.3% of the responses.

An alternative specification of each of the three models incorporated slope shifters. Only the share $(1 - A/M)$ specification [equation (10)] was significantly influenced by a slope interaction variable (between on-site and share). In this case the site dummy became insignificant, the interaction variable had limited dispersion, and the model fit was not noticeably different. Given these results, pooling of all respondent data into a single estimated model for each specification was judged appropriate.

Welfare Measures

Based on the estimation results, equivalent surplus welfare measures were calculated using each of the three specifications. The calculated mean and median values for each estimated distribution for both on-site and off-

Table 1. Whooping Crane Models, Parameter Estimation for Dichotomous Choice, Contingent Valuation Methods

	Model 1		Model 2		Model 3	
Variable	Logit	Probit	Logit	Probit	Logit	Probit
Intercept	−.316	−.216**[b]	−.602*	−.446*	−3.55*	−2.10*
	(−1.88)[a]	(−2.16)	(−3.76)	(−4.97)	(−2.56)	(−2.65)
Offer	−.024*	−.014*				
	(−8.57)	(−8.94)				
Log offer					−.824*	−.488*
					(−9.93)	(−10.50)
Log[1 − (offer/income)]			403.22*	193.35*		
			(6.60)	(7.08)		
Log income					.481*	.284*
					(3.58)	(3.73)
Club member	.899*	.532*	.936*	.584*	.881*	.519*
	(4.47)	(4.39)	(4.74)	(4.89)	(4.21)	(4.17)
On-site resp.	.634*	.383*	.554*	.345*	.617*	.364*
	(3.49)	(3.57)	(3.07)	(3.26)	(3.22)	(3.29)
Model $X^2(df)$	141.8(3)	139.2(3)	126.6(3)	120.7(3)	192.0(4)	192.4(4)
Correct predictions (%)	77.1	75.0	73.5	74.1	78.3	78.3
MRSQ	.15	.15	.14	.13	.21	.21
AIC	391.07	392.39	398.67	401.54	366.98	366.94
N	741	741	741	741	741	741

[a] Asymptotic t-values in parentheses.
[b] Single asterisk indicates significant at 1% level; double asterisk indicates significant at 5% level.

site respondents as well as by club membership are listed in table 2. They range from −$61 to $149. The estimated conditional logistic probability functions used to calculate these measures for off-site nonmember respondents are shown in figure 1.

The mean values were calculated by numerically integrating the area under each estimated willingness-to-pay function over the range of the offer amounts. Income was set at its sample mean ($26,742).[4] The mean equivalent surplus measures are considerably higher than the medians in all but one case. This occurs in spite of the downward bias on means caused by truncating the range of integration at the highest offer ($130). Doubling and tripling the range of integration increased the means as much as 75% (table 2). Hanemann's concern that the median would avoid truncation problems appears relevant in this case. Notably, in this application the truncation rule chosen has considerably less impact on the utility-theoretic specifications than on the logarithmic specification. The calculated means are relatively invariant to either the logit or probit estimation approach.

The medians vary considerably across specifications but are similar for logit versus probit models (table 2) except for the share model [equation (10)]. The linear specification proposed by Hanemann leads to a negative median value in three of the four nonmember cases. This result is disturbing. Although negative values may be feasible for some resources, e.g., poisonous snakes, certain viruses, etc., in this case they seem unreasonable. In opinion questions, less than 8% of the respondents indicated that the whooping

[4] Use of mean income is common where aggregation to a population is considered necessary, e.g., for evaluating public policy benefits. A preferred approach would be to subdivide the sample into cells based upon various relevant characteristics of the population of interest, calculate the relevant monetary estimate, and then aggregate to the population via a chosen aggregation rule (in most instances, a multiplicative rule attaching equal weight to individuals in each cell). Even if individual measures could be estimated for sampled respondents, this would not be of use unless the total population had been used, a perfectly random sample had been chosen and responded, the degree of nonrandomness were known, or if aggregation were not of interest. In the present case, simple mean income was utilized because interest is in comparison of resulting estimates across model estimation methods, specifications, statistical measures, and truncation rules. This is sufficient for our purposes but would not be appropriate for aggregation.

Table 2. Whooping Crane Annual Value Estimates and Their Sensitivity to Estimator, Model Specifications, Estimation Method, and Alternative Truncation Rules

Model Specifications[a]	Estimation Method	Interviewed On Site	Club Membership	α^* Adjusted Intercept	β^* Offer Coefficient	Median	Mean *WTP*			$Pr(WTP \leq A = .95)$		Range of $E(WTP)$ Estimates
							$130	$260	$390	A	Mean	
Hanemann1	Logit	No	No	−.316	−.024	-13.00	21.21	22.38	22.43	108	20.35	21–22
	Probit	No	No	−.216	−.014	-15.77	21.22	21.82	21.85	104	20.31	21–22
Hanemann2	Logit	No	No	−.602	403.22	-39.94	23.95	28.10	28.69	155	25.44	24–29
	Probit	No	No	−.446	193.95	-61.56	24.37	29.02	29.44	164	26.58	24–29
Logarithmic	Logit	No	No	1.353	−.824	5.17	21.00	27.35	31.50	184	24.06	21–32
	Probit	No	No	.795	−.488	5.10	20.65	25.71	28.51	148	21.60	21–29
Hanemann1	Logit	No	Yes	.583	−.024	23.99	39.13	42.00	42.12	145	40.02	30–42
	Probit	No	Yes	.316	−.014	23.07	39.68	41.97	42.01	143	40.46	40–42
Hanemann2	Logit	No	Yes	.334	403.22	22.14	45.92	55.92	57.43	216	54.29	46–57
	Probit	No	Yes	.138	193.95	19.02	48.48	62.55	64.57	244	61.83	48–65
Logarithmic	Logit	No	Yes	2.234	−.824	15.05	37.95	52.31	61.97	536	70.20	38–70
	Probit	No	Yes	1.314	−.488	14.77	38.14	52.00	60.64	529	62.69	38–63
Hanemann1	Logit	Yes	No	.318	−.024	13.09	33.16	35.37	35.47	134	33.37	33–35
	Probit	Yes	No	.167	−.014	12.19	33.88	35.50	35.54	132	33.99	34–36
Hanemann2	Logit	Yes	No	−.058	403.22	−3.82	35.68	42.65	43.67	191	40.48	36–44
	Probit	Yes	No	−.101	193.95	-13.92	37.65	46.90	48.00	212	45.22	38–48
Logarithmic	Logit	Yes	No	1.970	−.824	10.92	32.11	43.43	50.97	389	50.92	32–51
	Probit	Yes	No	1.159	−.488	10.75	32.22	42.74	49.07	313	45.64	32–49
Hanemann1	Logit	Yes	Yes	1.217	−.024	50.08	55.14	60.39	60.63	171	58.52	55–61
	Probit	Yes	Yes	.699	−.014	51.02	56.17	61.31	61.37	171	59.83	56–61
Hanemann2	Logit	Yes	Yes	.878	403.22	58.17	61.78	77.90	80.47	252	77.52	62–80
	Probit	Yes	Yes	.483	193.95	66.52	65.44	89.26	93.71	292	91.29	65–94
Logarithmic	Logit	Yes	Yes	2.851	−.824	31.82	53.84	78.14	94.96	1133	148.54	54–149
	Probit	Yes	Yes	1.678	−.488	31.14	53.88	88.44	94.98	906	132.36	54–132

[a] The number of observations are equal for all specifications in each table group and are 316, 47, 254, and 124 from top to bottom of the table, respectively. The models were estimated with a pooled sample of 741 respondents.

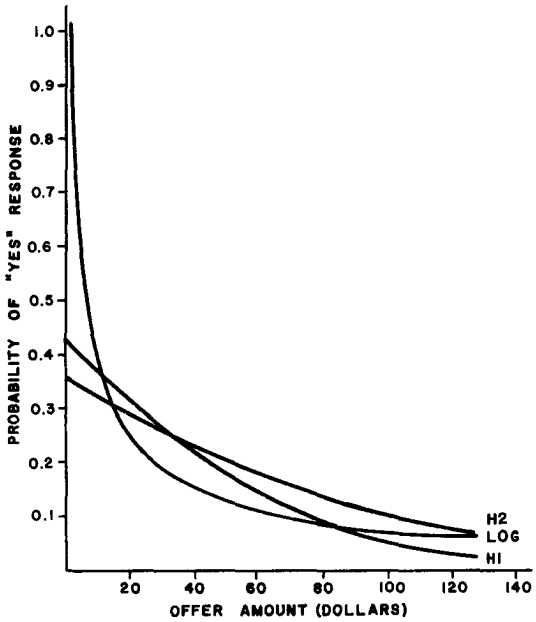

Figure 1. Off-site logit *WTP* probability functions for non-club member: Hanemann 1, Hanemann 2, and logarithmic specifications

cranes' continued existence was not important. Further, a negative value option was not given in the set of offers used in administration of the survey instrument. This follows from the assumption that willingness to pay is a nonnegative random variable in this case. As evidenced by figure 1, the source of the negative estimate of the median is the functional form itself. Given the distribution of respondent responses across offer amounts, the utility-theoretic specifications lead to a "yes" response probability less than 0.5 at the vertical intercept, i.e., probabilities are underestimated. This is confirmed by examination of the actual survey data. The median values from the logarithmic specifications do not suffer from the same problem.

In summary, the estimated specifications for the utility difference differ considerably. All models have respectable statistical fit, but as in previous studies the logarithmic model fits the data somewhat better. Although the utility-theoretic specifications examined here lead to negative estimates of the median WTP for nonmember respondents in three of four cases, these specifications are considerably less sensitive to the truncation rule chosen when estimating the mean WTP (last column, table 2). For the remaining nine nonnegative cases, all of the utility-theoretic specifications yield higher estimates of the median than their corresponding logarithmic specification. The latter specification is, thus, more conservative. In this study, median estimates appear more sensitive to model specification than the mean when identical truncation rules are used, e.g., $260.

If the ninety-fifth percentile of the estimated distribution were used as a truncation level, then the logarithmic specification yields higher estimates of $E(WTP)$ in three of four cases. However, when the highest offer amount ($130) used in the survey administration is used as a truncation point,[5] the estimate of $E(WTP)$ for the logarithmic model is equal to or lower than the utility theoretic specifications.

Discussion

There appears to be little statistical difference between the logit and probit estimation methods in this empirical application. Although the share model specification [equation (10)] indicates variation in estimated distribution medians, selection of the logit model seems justified based on simplicity when deriving the welfare change measures.

Hanemann's approach, i.e., specifying utility functions which when subtracted result in manageable estimating equations for the utility difference, does not avoid the problem of ad hoc specification of utility functions. The forms suggested by Hanemann did not perform as well in this study as an ad hoc logarithmic specification. Which is "better" is a judgment call by researchers. If Hanemann's approach is followed, better specifications for the utility function and the resultant utility differences must be discovered.

This case study also revealed that models with fairly similar statistical fits can lead to very disparate measures of economic value, regardless of whether the mean or median is chosen to estimate average *WTP*. Although use of expected value for equivalent surplus is a theoretically correct estimate of average sample *WTP*, it appears questionable on statistical grounds. The sensitivity of the mean to

[5] This $130 offer amount was selected after pretesting prior to the final survey administration. Use of truncation levels above this level for calculating *WTP* estimates represents extrapolation beyond the range of data for which the model was estimated.

truncation is very apparent in this study.[6] In dichotomous choice studies, pretesting offer ranges is often inadequate. Thus, observation of a high proportion of "yes" responses at the upper end of the range implies a larger *WTP* truncation is necessary to estimate the mean *WTP* more accurately. However, this involves a double-edged sword. Although the higher range is needed for accuracy, the reliability of the estimated distribution's tail is questionable.

When adequate pretesting of offer ranges is absent, the use of the median would avoid this truncation problem. The median also may provide a more conservative estimate of *WTP*. However, variation in medians across specifications suggests caution.

Concerning the economic value of the whooping crane resource, both income and wildlife-oriented organization membership led to an increased probability of offer acceptance. That is, both led to an increased *WTP* estimate for the whooping crane resource. Mean *WTP* was estimated to range from $21 to $149 depending upon the level of truncation used and functional specification; the majority of estimates were $70 or less. Estimates of *WTP* for mail survey respondents ranged from $21 to $70, with most less than $50. Estimated medians ranged from −$62 to $67. Each of these estimates is for an individual (although respondents may have answered for their households) and is expressed on an annual basis. Any attempt to aggregate across individuals (or households) would require identification of the relevant population and discounting to account for future time periods.

Conclusions

The preceding findings indicate that caution is necessary in applying dichotomous choice models in CVM studies. This is not to say that they should be avoided. To the contrary, these models can be applied with considerable success. Yet, those using this approach must recognize the limitations and report their results in a manner which will make others aware of the sensitivity of estimates to the issues of functional form, truncation, and the statistical estimator of *WTP* adopted, i.e., mean or median.

For applied policy analysis, economists often must choose or suggest an estimate. In the present case, the mean *WTP* estimate from the logarithmic specification using a truncation level of $130 seems most credible, based upon statistical fit, pretesting of offer ranges, and other considerations. However, given the empirical results reported, an annual estimate of *WTP* could fall within the $5 to $149 range (excluding the negative medians) depending upon which estimation approach was chosen. These alternative choices would result in significant differences in value when aggregating over the entire population of the United States; these differences would not be recognized if a single specification, estimation approach, statistical estimator, and truncation rule had been initially adopted. Clearly professional judgment plays a major role in making use of dichotomous choice survey methods.

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[6] Within specifications the mean was sensitive to truncation which, for the 24 cases and truncation rules chosen (table 2), led to variation greater than 40% in seven instances and greater than 100% in two instances. The average variation between high and low estimates was 40%.

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Appendix

Contingent Market Question

The contingent market question utilized in this study is reproduced below.

Each blank line space in the question was filled in with a specific offer amount ranging from $1 to $130. The amounts varied across respondents, with each respondent receiving only one offer amount for the question. Resource managers are interested in predicting the amount of future interest which people will have in wildlife. The next question presents a situation which asks for your best estimate of how you would react in the given circumstances. This situation does not represent any actual policy proposals under consideration.

Suppose that economic pressures and policy changes resulted in a decision to no longer fund programs to maintain the whooping crane population—a decision which would virtually insure the extinction of the whooping crane.

Suppose that an independent foundation was set up for the purchase and maintenance of refuge land so that the species might be preserved in the future. Supporting membership in the foundation would be available for $_____ per year for each person. Future access would be set up so that only those individuals who desire to visit and who contribute to the foundation each year would have the option to use the refuge areas. These people would pay no additional fees for visitation at these refuges. Other individuals who contributed, but did not intend to visit the refuges, would still have the satisfaction that they helped preserve the whooping crane.

If a supporting membership cost $_____ per year, would you become a member and help ensure the continued existence of the whooping cranes?
(Circle a number)

1. YES
2. NO