Journal of Agricultural and Resource Economics 24(2):572–583

Trichotomous Choice: A Possible Solution to Dual Response Objectives in Dichotomous Choice Contingent Valuation Questions

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We investigate the possibility that some respondents to a dichotomous choice question vote YES, even though they would not pay the posted dollar amount in order to register support for the project or policy. A trichotomous choice question format is proposed to determine if allowing respondents the opportunity to vote in favor of a project at an amount less than their bid affects estimated willingness to pay. Using univariate and multivariate tests, we find the trichotomous choice question format reduces the number of YES responses and produces a statistically significant decrease in willingness to pay for an open-space program.

Key words: contingent valuation, open space, willingness to pay

Introduction

A common finding in contingent valuation method (CVM) studies is that mean willingness to pay (WTP) estimated using the dichotomous choice question format exceeds mean WTP obtained using the open-ended question format (Walsh, Johnson, and McKean; Johnson, Bregenzer, and Shelby; Schulze et al.) or evokes different behaviors (Kealy and Turner). Based on studies that have estimated WTP using both question formats, the median of the ratios of dichotomous choice WTP to open-ended WTP is about 2-to-1 (Brown et al.; Schulze et al.). Open-ended CVM is certainly not a criterion for judging the accuracy of the dichotomous choice format, but repeated findings that the two methods produce different results suggest that we might learn more about the motivations of CVM respondents by exploring reasons for the difference.

A more serious concern for dichotomous choice CVM is that it appears to significantly overestimate actual cash payments. This result was found for donations to a public good (Brown et al.), and even for payments to acquire a private good (Loomis et al.). Despite

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The authors appreciate the suggestions on survey design by Marcella Wells, Maureen Donnelly, and George Wallace, Colorado State University. Deb Pearson and Julia Trombley of the City of Loveland, as well as members of the Open Lands Commission, were quite helpful in the survey design. Without implicating in any way, we would like to thank Richard Carson and Kevin Boyle for comments on the initial concept of the trichotomous choice question format. David Harpman and Michael Welsh provided assistance on the details of the statistical analysis routine, and Steve Koontz provided assistance with the exposition of the probability model. We would also like to thank two anonymous journal reviewers for helpful suggestions in improving the manuscript. However, only the authors are responsible for what follows.

the desirable theoretical properties of the dichotomous choice CVM format (Hoehn and Randall), the method appears to overestimate actual WTP.

Brown et al. hypothesize that the dichotomous choice CVM format presents a quandary to individuals who would not pay the bid amount, but nevertheless want to register support for provision of the public good. Individuals may have not one, but two, objectives in responding to a hypothetical WTP question. First, they may want to truthfully answer the question asked about their actual willingness to pay. Second, they may want to indicate whether they view the good favorably. An open-ended response allows respondents to meet both objectives even if their WTP is low—they simply report their nonzero dollar value. With the dichotomous choice format, only a YES response indicates a positive attitude about the good.

Respondents who want to indicate a favorable impression of the public good but who would not pay the posted amount may experience a conflict, because they cannot meet both objectives with their response. They may believe a NO response sends the wrong message—that they do not value the good at all—when in fact they do. If the posted bid level is more than the respondent thinks he or she would be willing to pay, the respondent must choose between the two objectives; if it is more important to indicate a favorable impression of the good than to indicate a truthful WTP, the respondent will say YES.

This response strategy could be one explanation for the frequent difference in WTP elicited from dichotomous choice and open-ended WTP question formats. It also could be one explanation for the difference between dichotomous choice CVM estimates of WTP and actual cash payments found in the two studies cited above. With actual cash payments, the objective of indicating a favorable impression of the good is likely to be discounted because meeting that objective requires a cash outlay. To circumvent this potential problem with dichotomous choice CVM, we propose a trichotomous choice question format to provide two possibilities for an affirmative response; the new choice is an affirmative response at some amount less than the posted bid.

Our trichotomous choice question presents all three response options at once. Thus it is similar to the multiple-bounded question format of Welsh and Bishop. However, our format uses much less space in the survey booklet and is less taxing than having individuals respond to each and every bid amount.

The Trichotomous Choice Model

The trichotomous choice question provides individuals with the following three response categories:

1. I would vote against program Q, even if there is no cost to my household.
2. I would vote for program Q only if the cost to my household were less than $\$C$ per year.
3. I would vote for program Q if it cost my household $\$C$ per year.

The decision process for the utility-maximizing respondent can be thought of as follows. If the utility obtained from having provision of the public good (Q_1) is greater than the reduction in income (I) from the bid amount the respondent is asked to pay ($\$C$), the respondent will select choice No. 3 above. More formally, if the deterministic

part of the utility difference, $(v(Q_1, I - \$C)) - (v(Q_0, I))$, is greater than the stochastic part of the utility difference $(\epsilon_1 - \epsilon_0)$, the respondent will answer YES to the bid amount ($\$C$), i.e., will select choice No. 3, voting in favor at $\$C$. If the utility difference is distributed logistically, then the probability of selecting choice No. 3 at $\$C$ is given in equation (1):

$$\Pr(WTP \geq \$C) = \left[1 + \exp(B_0 - B_1(\$C))\right]^{-1}. \tag{1}$$

If instead the respondent selects the second option, then the respondent's WTP is positive but less than $\$C$. Specifically, the probability of observing choice No. 2 is:

$$\Pr(\$0 < WTP < \$C) = \left[1 + \exp(B_0)\right]^{-1} - \left[1 + \exp(B_0 - B_1(\$C))\right]^{-1}. \tag{2}$$

Finally, if the respondent selects the first option (choice No. 1), then that respondent's WTP is less than or equal to zero. Whether to make this a strict equality depends on the nature of the good. If the good results in an unambiguous improvement in net well-being, such as an improvement in health or provision of open space, then a strict equality is sensible. However, if the good involves a nonmarket gain and a *nonmarket* loss not reflected on the cost side in the benefit/cost analysis, such as removal of a dam which entails loss of reservoir recreation but a gain in river recreation, then an inequality is quite possible for those individuals preferring reservoir recreation. In this case,

$$\Pr(-\infty < WTP \leq 0) = 1 - [1 + \exp(B_0)]^{-1}. \tag{3}$$

Comparing Response Strategies with Dichotomous and Trichotomous Choices

The conventional interpretation of the utility difference problem solved by the respondent in the standard dichotomous choice question yields two reasons individuals would respond NO: (*a*) they would desire the project *if* it cost some amount less than $\$C$ posted in the survey (i.e., $0 < WTP < \$C$), or (*b*) they would not care for the resource even if it were free.

While individuals in category (*b*) will most certainly give a NO response, those in category (*a*) face the dual response objective. Some α proportion of these individuals find themselves in a situation where, despite the fact that $WTP < \$C$, they would respond YES to register support for provision of the public good, while $1 - \alpha$ individuals would respond NO. If α is nontrivial, the standard dichotomous choice question format would yield too many YES's and too few NO's, resulting in an overestimate of WTP. This may partially explain why WTP from a dichotomous choice question is often larger than from an open-ended WTP question—because in the open-ended format, stating any positive dollar amount signals support for the good. In comparison to dichotomous choice, the trichotomous choice CVM question format provides a separate category for respondents finding themselves in the $(0 < WTP < \$C)$ category, and should reduce or eliminate the α proportion of false YES at $\$C$ responses.

The trichotomous approach, if supported by repeated testing, would have two advantages over the standard dichotomous choice CVM. First, the three-response format more accurately depicts the real number line along which respondent WTP actually lies than does the dichotomous choice question format. In particular, a YES response in dichotomous choice assigns a positive probability that an individual's WTP is greater than or equal to the bid amount. If the "dual response objective" hypothesis is true, α of these individuals do not belong in this portion of the real number line. Rather, these individuals belong at some positive WTP that is less than the bid amount. Therefore, the trichotomous question format may provide a more valid estimate of actual WTP since α of those people with some positive WTP that is less than the bid amount will not be indicating they would pay the bid amount in order to register support for the policy.

The second advantage of the trichotomous approach is one similar to that of the double-bounded dichotomous choice—a gain in statistical efficiency. The trichotomous choice question format, like the double-bounded and multiple-bounded models, allows greater resolution of the location of the NO responses along the real number line, reducing the variance in WTP. The responses to the trichotomous choice question are analyzed using the multiple-bounded GAUSS program of Welsh and Bishop. Their approach brackets WTP as shown in equations (1)–(3). The GAUSS program is based on the logistic distribution, and thus provides distributional comparability to the dichotomous choice CVM approach analyzed with a binary logit model.

Hypothesis Tests

The null hypothesis of behavioral consistency of dichotomous choice (DC) with the utility difference model would be indicated by finding independence of YES responses to question format. Specifically, the null of no statistical dependence of *YES* responses at a given bid amount to *DC* question format versus trichotomous choice (*TRICC*) question format is:

$$(4) \qquad H_0: \; DC_{observed}(YES \mid \$C) = TRICC_{observed}(YES \mid \$C).$$

If the "dual response objective" hypothesis is true, then there is not independence of YES responses to question format, i.e., the observed number of *YES* to *$C* in the standard dichotomous choice question format should be significantly greater than in the trichotomous choice question format (and correspondingly, too few NO's are observed in the standard dichotomous choice question format). Therefore, we would reject the null hypothesis in equation (4) in favor of the alternative:

$$(5) \qquad H_a: \; DC_{observed}(YES \mid \$C) > TRICC_{observed}(YES \mid \$C).$$

A test for independence between two qualitative variables (e.g., YES response and question format) is the chi-square test (Bailey). To perform this univariate test, trichotomous choices No. 1 and No. 2 were coded as NO responses, as they would be under the null hypothesis.

Two multivariate statistical tests involve: (*a*) whether the question format causes a significant shift in the logistic distribution (i.e., location), holding other variables constant, and (*b*) whether the two question formats yield the equivalent slope coefficients (i.e., scale) on the logistic distribution.

To perform the intercept shifter test, we estimate the pooled model:

$$\log(YES/1 - YES) = \beta_0 + \beta_1(COST) + \beta_2(RECIMP) + \beta_3(VERSION), \tag{6}$$

where *YES* = yes, would pay *COST*; *COST* = the dollar amount households are asked to pay; *RECIMP* = importance of lands that have potential for developed recreation facilities such as ball fields, parks, and golf courses; and *VERSION* = 0 if the standard dichotomous choice question is asked, and 1 if the trichotomous choice question is asked.

This intercept test involves comparing

$$H_0: \beta_3 = 0 \quad \text{versus} \quad H_a: \beta_3 < 0. \tag{7}$$

We expect a negative sign as the alternative for the reasons given in the previous section of the article. Thus, this is tested using a one-sided *t*-test on β_3.

The second multivariate test involves estimating separate logit models for the two question formats, and then a combined model using pooled data from the two question formats. The null hypothesis of coefficient equality is:

$$H_0: \quad \beta_0 = \delta_0, \quad \beta_1 = \delta_1, \quad \beta_2 = \delta_2, \tag{8}$$

where the β's are coefficients from the dichotomous choice question and the δ's are coefficients from the trichotomous choice question. The null hypothesis is tested using a likelihood-ratio test. The test statistic determines if there is a significant difference between the sum of the individual log-likelihood values and the log-likelihood value from the pooled model. If the null hypothesis of coefficient equality is accepted, there should be no significant difference between the sum of the two individual model log-likelihood values and the one log-likelihood value from the combined model. The likelihood-ratio test is distributed chi-squared.

The last test evaluates whether the key variable of policy interest (mean *WTP*) is statistically different using the two different question formats. Mean *WTP* is given by Hanemann as:

$$\text{Mean } WTP = [\ln(1 + \exp(\beta_0 + \beta_2(RECIMP)))]/|\beta_1|. \tag{9}$$

Since mean *WTP* is the ratio of estimated coefficients, calculation of confidence intervals requires either bootstrapping or a simulation approach. We adopt the simulation approach of Park, Loomis, and Creel, which uses the variance-covariance matrix. If the confidence intervals do not overlap, we can conclude that WTP estimates using the two question formats are statistically different.

Data

Survey Design

The data were derived from a mail survey of City of Loveland, Colorado, residents. Much like the rest of Colorado, Loveland has experienced rapid population growth, sprawl-type land use, and accompanying loss of open space. Other local governments have passed sales tax add-ons to fund open-space acquisition.

A short survey was developed to be included in residents' utility bills. As such, the survey had severe constraints in terms of size and length; nonetheless, it followed the basic format of most contingent valuation questionnaires. Prior to the WTP questions, individuals were given an opportunity to consider the relative importance of different types of open space. For example, individuals were asked to rate open space for recreation such as parks, golf courses, and ball fields versus open space to protect wildlife or as a buffer between communities.

The survey then described the current state of open space in Loveland:

> Currently, 4% (587 acres) of the City of Loveland is dedicated as parks and golf courses, and 0% is dedicated to natural areas.... We need to know whether you wish to pay for additional open space by purchase of land from willing sellers.... Therefore, we are interested in whether you would pay additional sales tax for more open space.

Three WTP questions were asked—one for recreation open space, one for natural area open space, and one that provided equal amounts of land for both recreation and natural areas. For example, the wording of the natural areas question was:

> Alternatively, with the increase in the city sales tax, the city could acquire the same acres and leave the area undeveloped as natural areas. To add these natural areas would cost your household $____ each year for 10 years.

The blank $____ was filled in with a dollar amount ranging from $1 to $150. This range of dollar amounts was selected based on pretesting and prior studies on open space.

To test the concern over mixed motives in household response to the standard dichotomous choice CVM question, two different WTP questions were asked following this same introductory scenario. The standard dichotomous question was:

> If this were the only issue you had to vote on today, would you vote in favor of paying this amount of money to acquire this additional amount of open space? [ ] YES [ ] NO

The three-part or trichotomous choice WTP question was:

> Please check one of the three choices below to indicate how you would vote if this were the only issue you had to vote on today.
>
> [ ] I would vote *against* the additional acres of open space even if there is no cost to households such as mine.
>
> [ ] I would vote *for* the additional acres of open space only if it cost my household *less* than $____ each year for 10 years.
>
> [ ] I would vote *for* the additional acres of open space at a cost to my household of $____ each year for 10 years.

Thus, the framing of the language for the two WTP question formats was as parallel as possible, with the key difference being refinement of reasons for voting YES under the trichotomous choice scenario. Specifically, the respondent could signal a desire to have open space without agreeing to pay the full dollar bid amount by selecting the second choice under the three-part WTP question.

Sample Frame

Names of utility customers in the City of Loveland were drawn at random from every billing cycle. This sample is quite comprehensive in coverage, including both homeowners and renters, as many renters pay for their own utilities. There was random assignment of households in each cycle to the two different survey versions. We performed a first mailing, followed by a reminder postcard and a second mailing. As an incentive to respond, households were informed that respondents would be entered into a drawing for a $100 credit on their utility bill.

Results

Response Rate

Of the 500 standard dichotomous choice surveys, nine were undeliverable and 154 were returned after two mailings, giving a response rate of 31.4%. Of the 502 trichotomous choice WTP question surveys, eight were undeliverable and 176 were returned after two mailings, for a response rate of 35.6%.

While the response rates are lower than desirable, the key focus for this methodological comparison is similarity in response rates. To further investigate the comparability of the two samples, we checked for similarities in demographics. Age was nearly identical (51 years versus 52.75 years), as was education (14.7 years versus 14.6 years). There was no significant difference in income.

Test of Independence of YES Responses to Question Format

Table 1 presents the number and percentage of YES and NO responses for each open-space purchase program under each survey treatment. To implement the chi-square, the two trichotomous choice responses—(*a*) NO at zero cost, and (*b*) YES, but at a cost less than the bid—are coded as NO responses for consistency with the dichotomous choice response format. The results of the chi-square test of independence between YES (NO) responses and question format are also shown in table 1.

Despite the fact that the mean of the bid amounts is slightly lower for the returned surveys in the trichotomous choice sample, in all three open-space programs the percentage of YES responses is higher with dichotomous choice than with trichotomous choice. For the nature lands and the combined nature/recreation lands, we can reject the null hypothesis of independence of YES responses across question formats. Specifically, in the nature lands and combined nature/recreation lands WTP questions, there are

Table 1. Comparison of Number and Percentage of YES and NO Votes, Dichotomous Choice vs. Trichotomous Choice, for Open-Space Purchases

	Standard Dichotomous Choice			Trichotomous Choice			
Open-Space Program	Response	No.	%	Response	No.	%	χ^2
Recreation Lands	YES	84	59.0	YES	85	54.8	0.563
	NO	58	41.0	NO	70[a]	45.2	
				[a]NO @ no cost = 20; YES @ cost < bid = 50			
	Mean posted bid = $33.60			Mean posted bid = $32.54			
Nature Lands	YES	86	60.5	YES	73	47.0	5.4*
	NO	56	39.5	NO	82[b]	53.0	
				[b]NO @ no cost = 31; YES @ cost < bid = 51			
	Mean posted bid = $33.94			Mean posted bid = $32.48			
Both Land Types	YES	85	59.4	YES	58	37.0	14.4**
	NO	58	40.6	NO	97[c]	63.0	
				[c]NO @ no cost = 35; YES @ cost < bid = 62			
	Mean posted bid = $45.90			Mean posted bid = $44.21			

Note: Single and double asterisks (*) denote significantly different at the .05 and .01 levels, respectively.

significantly more YES responses with the standard dichotomous choice question format ($p = .05$ and .01, respectively). This suggests that some households may be stating YES they would pay in the standard dichotomous choice format, but choosing "would pay some amount less than the bid" when offered the trichotomous choice format. Thus, question format and YES responses are not independent.

Test of Intercept Shifter

Table 2 reports results of the three logit models that pool data from the two WTP question formats in order to test whether question format results in a shift in the logistic distribution. Similar to the test of independence, question format has a statistically significant effect in the nature lands program ($p = .05$) and combined recreation/nature lands program ($p = .01$). The negative sign indicates that the probability the household would pay the bid amount goes down if the trichotomous choice question format is used.

Test for Coefficient Equality

For the test of the null hypothesis in equation (8), two separate logit models were estimated for each question format and compared to the pooled model in terms of log-likelihood function. Results of this likelihood-ratio test suggest we reject equality of

Table 2. Results of Multivariate Test of Survey Version Significance

	Recreation Lands		Nature Lands		Both Land Types	
Variable[a]	Coefficient	*p*-Value	Coefficient	*p*-Value	Coefficient	*p*-Value
Constant	-1.191	0.004	-0.992	0.041	-0.791	0.055
COST	-0.015	0.000	-0.014	0.000	-0.011	0.000
RECIMP	0.665	0.000	—	—	0.548	0.000
NATIMP	—	—	0.519	0.000	—	—
VERSION	-0.229	0.370	-0.752	0.003	-1.069	0.000
N	305		309		306	
Log likelihood	-181.47		-188.62		-184.03	
Model χ^2	53.79*		49.97*		55.65*	

Note: An asterisk (*) denotes statistical significance at the .01 level.

[a] *COST* = the dollar amount respondent was asked to pay; *RECIMP* = importance (1–5 scale) of lands that have potential for developed recreation facilities (e.g., ball fields, parks, golf courses); *NATIMP* = importance (1–5 scale) of natural areas that provide public access for undeveloped recreation (e.g., hiking, birdwatching); and *VERSION* = 1 if trichotomous choice, 0 if standard dichotomous choice.

coefficients across the two different question formats for the nature lands and the combined nature/recreation lands programs, but not for the recreation lands program. Specifically, the calculated χ^2 is 13.20 for the nature lands program and 23.07 for the combined nature/recreation lands program. The critical χ^2 at the .05 level with four degrees of freedom is 9.49. Thus, the trichotomous choice question format results in different slope coefficients, including the critical slope of the bid coefficient.[1]

Test for Differences in Mean WTP

Table 3 presents the logit coefficients for the standard dichotomous choice question format that are used to calculate mean WTP using the formula in equation (9). The cost coefficient is negative and significant, while the taste/preference variable is positive and significant. Table 4 presents the results of the multiple-bounded logit estimation using the trichotomous choice responses. The added statistical efficiency of this approach is evidenced by the greater number of coefficients that are significant at the .01 level.

Table 5 reports the means and 95% confidence intervals calculated from the logit equation results shown in tables 3 and 4. In all three cases, mean WTP is significantly lower when using the trichotomous choice question format. In fact, the dichotomous choice WTP is about three times larger than the trichotomous choice WTP for each open-space program. While it is difficult to know the "true" WTP for public goods such as open space, the lower WTP from the trichotomous choice model moves the mean WTP estimate in the direction of: (*a*) what might have been obtained using an open-ended WTP

[1] As pointed out by a reviewer, for the intercept and slope coefficient tests to indicate mean differences between survey question formats, the variance of the two methods must be constant.

Table 3. Results of Binary Logit Equations Used to Calculate WTP: Standard Dichotomous Choice Question

	Recreation Lands		Nature Lands		Both Land Types	
Variable	Coefficient	*p*-Value	Coefficient	*p*-Value	Coefficient	*p*-Value
Constant	-1.560	0.009	-0.501	0.461	-1.640	0.009
COST	-0.011	0.020	-0.010	0.022	-0.013	0.001
RECIMP	0.735	0.000	—	—	0.853	0.000
NATIMP	—	—	0.352	0.036	—	—
N	139		141		140	
Log likelihood	-81.98		-88.14		-76.82	
Model χ^2	24.20*		14.41*		34.82*	

Notes: An asterisk (*) denotes statistical significance at the .01 level. For definitions of variables, refer to notes to table 2.

Table 4. Results of Multiple-Bounded Logit Equations Used to Calculate WTP: Trichotomous Choice Question

	Recreation Lands		Nature Lands		Both Land Types	
Variable	Coefficient	*p*-Value	Coefficient	*p*-Value	Coefficient	*p*-Value
Constant	-0.643	0.167	-1.763	0.002	-0.565	0.190
COST	-0.044	0.000	-0.048	0.000	-0.036	0.000
RECIMP	0.728	0.000	—	—	0.458	0.001
NATIMP	—	—	0.775	0.000	—	—
N	155		155		155	
Log likelihood	-160.00		-165.96		-208.285	
Wald Statistic	71.00*		71.82*		75.62*	

Notes: An asterisk (*) denotes statistical significance at the .01 level. For definitions of variables, refer to notes to table 2.

Table 5. Comparison of Mean WTP and 95% Confidence Intervals, Dichotomous Choice vs. Trichotomous Choice

	Dichotomous Choice		Trichotomous Choice	
Open-Space Program	Mean WTP	95% Confid. Interval	Mean WTP	95% Confid. Interval
Recreation Lands	$108	66–510	$42	34–52
Nature Lands	$116	71–490	$30	25–40
Both Land Types	$106	73–221	$34	27–44

question format, potentially reducing procedural variance in estimates, and (*b*) what other studies suggest would be the actual cash payment. However, further testing of the trichotomous choice question format against open-ended and actual cash WTP is needed before one can ascertain the degree of improvement offered by the trichotomous choice WTP question format.

Conclusion

This investigation was motivated by the finding that dichotomous choice CVM estimates of WTP are often twice those of open-ended WTP, and by the concern that dichotomous choice CVM estimates are larger than actual cash WTP. This may be due to the possibility that respondents to a dichotomous choice CVM question may face dual response objectives that cannot be met with a single response. If individuals think the good is worthwhile, but only if provided at a price less than the bid amount, they must choose between providing an honest response (i.e., NO) and providing a response that indicates their support for providing the public good. Faced with this dilemma, some individuals may opt for a YES response even at a bid amount in excess of their "true" WTP. We tested a three-part WTP question that gives individuals facing this quandary the option to respond "YES, but at a lower price."

Results from a comparison of the standard dichotomous choice format and this trichotomous choice format indicate that offering this third alternative reduces the proportion of YES responses and significantly lowers mean WTP. While we believe this result is driven by the "dual response objective hypothesis," it is also consistent with another explanation—i.e., that given the chance to understate their maximum WTP, some people may take it. While this understatement is quite likely with actual cash payments, we doubt it is common in CVM because respondents to questions about hypothetical payments for desirable public goods may have little incentive to understate their WTP. However, this is a conjecture on our part. The necessary next step is a direct comparison of the trichotomous choice question format to open-ended WTP questions and actual cash payment in an experiment that avoids free-riding behavior in the actual cash payment treatment.

[*Received October 1998; final revision received June 1999.*]

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