Measuring the environmental value of Saeng Island in Busan, Korea with allowing for zero values

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ABSTRACT

This paper attempts to deal with zero willingness to pay (WTP) responses from dichotomous choice (DC) contingent valuation (CV) surveys. It also will apply a recently proposed one-and-one-half-bound (OOHB) question format in order to obtain an appropriate welfare measure such as the mean WTP. To this end, the spike model suggested by Kriström (1997) is adjusted and applied to modeling OOHB DC-CV data with zero WTP responses. The mean WTP per household was 2,716 Korean won per annum and the overall results show that the OOHB spike model outperforms the conventional OOHB model significantly.

Key words: willingness to pay, contingent valuation, spike model, one-and-one-half-bound

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1. Introduction

Coastal resources provide various important benefits to our lives. These benefits include biophysical and environmental values as well as social and commercial ones. Experts and professionals with an interest in and responsibility for i) protecting coastal environmental assets (or natural resources) and ii) managing national/local environmental planning and program, should have a clear concept designed to give quantitative measures of the environmental benefits from natural assets. The major coastal assets in Korea range from water and sediment quality, beaches, local and national marine parks, coastal habitats to endangered species and other biological resources.

This paper aims to examine the socioeconomic benefit of a proposed regulatory management policy on the protection of an uninhabited island located in the southeastern part of Korea, Saeng Island by using the economic valuation method.[1] In order to measure the value of Saeng Island in Busan, Korea, a contingent valuation (CV) was applied to quantify the economic value to households in Korea for implementing the island conservation and management policy.[2] More specifically, we apply the one-and-one-half-bound (OOHB) dichotomous choice (DC) question format recently proposed by Cooper *et al.* (2002) that can reduce the potential for response bias in multiple-bound formats such as the double-bound model while maintaining much of its efficiency gains.

In the sample used in this study, it happened that 60.5% of all respondents reported zero willingness to pay (WTP). In practice, zero WTP responses which are often found in DC-CV studies act as a corner solution of the consumers' utility-maximization when the goods and services to be valued do not contribute at all to the individual's utility (e.g., Yoo *et al.*, 2001; Strazzera *et al.*, 2003). One alternative to deal with zero WTP responses is to use the spike model as suggested by Kriström (1997). This model takes into account a spike at zero that is the truncation, at zero, of the negative part of the WTP distribution.[3]

The spike model is, therefore, adjusted and applied to modeling OOHB DC-CV survey data with zero WTP responses in order to obtain an appropriate welfare measure such as the mean WTP. As shown in Section 3, ignoring information at zero may influence the results significantly.

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1 Management is directed by the Act on the Conservation and Management of Uninhabited Islands become effective in August 2007.

2 Researches applying contingent valuation to Korean coastal resources and natural assets are recently active, and previous ones have only focused on valuing wetland (Kwak *et al.*, 2007; Pyo *et al.*, 2001), national marine park (Kwak *et al.*, 2002) and estuary (Yoo, 2007), not that of the uninhabited island.

3 The spike model was originally proposed for single-bound DC-CV model. Yoo and Kwak (2002) used the spike model in a double-bound DC-CV setting.

2. Models

2.1 Conventional OOHB DC-CV model

In the OOHB survey design, the respondent is given two prices up front and told that, while the exact cost of the goods to be valued is not known for sure, it is known to lie within the range bounded by these two prices. One of the two prices is selected at random and the respondent is asked whether she/he would be willing to pay this amount; she/he is then asked about the other price only if doing so would be consistent with the stated price range.

According to Cooper *et al.* (2002), the OOHB DC-CV model can be described as follows. Let $i=1,...,N$ be the index for each respondent in the sample and A be the bid amount presented to a respondent. Each respondent is presented with two prices, A_i^L and A_i^U where $A_i^L < A_i^U$. If A_i^L is randomly drawn as the first price, then the possible responses are yes-yes, yes-no and no. If A_i^U is randomly drawn as the first bid, then the possible answers are yes, no-yes and no-no. Binary-valued indicator variables of these six possible outcomes are I_i^{YY}, I_i^{YN}, I_i^N, I_i^Y, I_i^{NY} and I_i^{NN}, respectively,

such that:

$$\begin{aligned}
&I_i^{YY}=1(i\text{th respondent's response is 'yes-yes'})\\
&I_i^{YN}=1(i\text{th respondent's response is 'yes-no'})\\
&I_i^{N}=1(i\text{th respondent's response is 'no'})\\
&I_i^{Y}=1(i\text{th respondent's response is 'yes'})\\
&I_i^{NY}=1(i\text{th respondent's response is 'no-yes'})\\
&I_i^{NN}=1(i\text{th respondent's response is 'no-no'})
\end{aligned} \tag{1}$$

where $1(\cdot)$ is an indicator function, whose value is one if the argument is true and zero otherwise.

WTP (hereafter denoted as C) is recognized as a random variable with a cumulative distribution function (cdf) defined here as $G_c(\cdot;\theta)$, where θ is a vector of parameters. Given the assumption of a utility-maximizing respondent, the log-likelihood function takes the form:

$$\begin{aligned}
\ln L = \sum_{i=1}^{N}\Big\{&\left(I_i^{YY}+I_i^{Y}\right)\ln\left[1-G_C\left(A_i^U;\theta\right)\right]\\
&+\left(I_i^{YN}+I_i^{NY}\right)\ln\left[G_c\left(A_i^U;\theta\right)-G_C\left(A_i^L;\theta\right)\right]\\
&+\left(I_i^{N}+I_i^{NN}\right)\ln G_c\left(A_i^L;\theta\right)\Big\}
\end{aligned} \tag{2}$$

Following the practice of previous studies, formulating $1-G_C(\cdot)$ as logistic cdf and combining this with $\theta=(a, b)$ yields:

$$G_C(A;\theta)=[1+\exp(a-bA)]^{-1} \tag{3}$$

Let C^+ be the mean WTP when C can be positive or negative and C^{++} be the mean WTP when C must be greater than or equal to zero. Welfare measures based on Equation (3) can be computed as follows:

$$C^+=a/b \tag{4}$$
$$C^{++}=(1/b)\ln[1+\exp(a)] \tag{5}$$

2.2 Spike model in OOHB DC-CV setting

The spike model is adjusted to modeling OOHB DC-CV data in this subsection. It is noted that the 'no' and 'no-no' respondents are composed of two groups: those who really have a zero WTP and those who have a positive WTP that is less than A_i^L. For people who gave a 'no' or 'no-no' response, an additional follow-up question was asked: 'Are you willing to pay anything at all?' Those providing a 'no' answer to this question represent a valid representation of their zero WTP. Thus, 'no' answers to the question after deleting protest zeros are taken as zero WTP responses.

For people who were asked the additional follow-up question, the two binary-valued indicator variables can be defined as:

$$\begin{aligned} I_i^{AY} &= 1(i\text{th respondent's response to the additional question is 'yes'}) \\ I_i^{AN} &= 1(i\text{th respondent's response to the additional question is 'no'}) \end{aligned} \tag{6}$$

To estimate the distribution of WTP, WTP is assumed to be distributed as a logistic on the positive axis. The log-likelihood function for the OOHB spike model is given by:

$$\begin{aligned} \ln L = \sum_{i=1}^{N} \Big\{ & \left(I_i^{YY}+I_i^{Y}\right)\ln\left[1-G_C\left(A_i^U;\theta\right)\right] \\ & +\left(I_i^{YN}+I_i^{NY}\right)\ln\left[G_c\left(A_i^U;\theta\right)-G_C\left(A_i^L;\theta\right)\right] \\ & +I_i^{AY}\left(I_i^{N}+I_i^{NN}\right)\ln\left[G_c\left(A_i^L;\theta\right)-G_C(0;\theta)\right] \\ & +I_i^{AN}\left(I_i^{N}+I_i^{NN}\right)\ln G_c(0;\theta)\Big\} \end{aligned} \tag{7}$$

where:

$$G_C(A;\theta)=\begin{cases}[1+\exp(a-bA)]^{-1} & \text{if } A>0\\ [1+\exp(a)]^{-1} & \text{if } A=0\\ 0 & \text{if} A<0\end{cases} \tag{8}$$

Thus, the spike is defined by $[1+\exp(a)]^{-1}$. Using (8), the mean WTP in the spike model can be calculated as:

$$C^{+}=(1/b)\ln[1+\exp(a)] \tag{9}$$

3. Empirical results

3.1 Data

The empirical findings of this study are based on the data from a survey conducted in 2006 to value a proposed conservation and management policy of Saeng Island in Busan, the second largest city of Korea. In order to draw a random sample of the residents of Busan, sampling was conducted by a professional polling firm. The survey was implemented by face-to-face interviews with well-trained interviewers to offer the most scope for detailed questions and answers. The survey questionnaire was set up with the assistance of experts at the polling firm. The pre-testing was done using a small focus group (30 persons) assembled to discuss their understanding of and reaction to the questions prior to main survey. As a result, the questionnaire and visual aids made it easier to understand the general information about the Island and were simplified because the overall perceptions of the group of the environmental importance of the Island were high.

The questionnaire format consists of i) introductory questions like respondents' perception after general background information on the Island, ii) respondents' attitudes toward various characteristics of the Island, iii) yearly WTP question for proposed policy of conserving and managing the Island and iv) household information. 60.5% of the respondents reported a zero WTP. The spike model, therefore, appears to be ideally suited for estimating WTP in the sample, since a sizable fraction of the population has a zero WTP.

3.2 Empirical results

The conventional model in (2) and the spike model in (7) were estimated by the maximum likelihood estimation method. The conventional model assumes that the additional follow-up question has not been used. Table 1 describes the estimation results. All the parameters in the spike model are statistically significant at the 1% level, while the constant term in the conventional model is not. Welfare measures are also provided in Table 1 To estimate the mean WTP, we used equation (4) in the conventional model and equation (9) in the spike model. Several interesting findings emerge from these results.

The conventional model gives an estimated mean of -307 won per annum and an estimated t-statistic of -0.38.[4] Thus mean WTP is not statistically significant at the 5% confidence level. However, the mean WTP in the spike model, computed as 2,716 Korean won per annum, is significant at the 1% level. Moreover, the Monte Carlo simulation technique of Krinsky and Robb (1986) was used with 5,000 replications to get the 95% confidence intervals for the point estimates of mean WTP. The confidence interval of the mean in the spike model is quite tight, while that in the conventional model is not and even includes zero. The information at zero drastically decreases the standard error of the mean and makes the confidence interval fairly tight in this application.[5]

Table 1. Estimation results for the conventional and the spike models

Variables	Conventional model	Spike model
Constant	-0.0709 (-0.39)	-0.4125 (-4.09)*
Bida	-0.2310 (-7.94)*	-0.1871 (-10.95)*
Spike		0.6017 (24.31)*
Number of observations Log-likelihood	400 -280.9	400 -447.3
Mean WTP Standard error[b] *t*-value 95% confidence interval[c] Truncated mean WTP Standard error[b] *t*-value 95% confidence interval[c]	-307 813 (-0.38) [-1,934-885] 2,850 261 (10.93)* [2,460-3,363]	2,716 268 (10.12)* [2,321-3,214]

Notes: The numbers in parentheses below the coefficient estimates are *t*-values, computed from the analytic second derivatives of the log-likelihood. * indicates significance at the 1% level. [a] The unit of measurement is 1,000 Korean won. [b] Standard errors are computed by the use of the delta method. [c] The confidence intervals are calculated by the use of the Monte Carlo simulation technique of Krinsky and Robb (1986) with 5,000 replications.

The household truncated mean WTP in the conventional model is computed to be 2,850 Korean won per annum, which is statistically significant at the 1% level. Thus,

4 At the time of the survey, GBP 1.0 was approximately equal to 1,900 Korean won.

5 Several other models (not reported here to save space), including covariates, were estimated. They imply that the likelihood of reporting ‘yes’ to a given bid is positively correlated with income, as expected. Adding covariates does not change the qualitative conclusions.

there is no significant difference between the mean in the spike model and the truncated mean. This result can be interpreted as indicating that a conventional analysis with truncation of the integral at zero provides a reasonable approximation to the spike model (Hanemann and Kriström, 1995). However, without information at zero it is not clear that the integral should be truncated at this point when computing the mean WTP. In addition, the formula for the truncated mean has an unclear interpretation and inconsistent logic and hence is *ad hoc* (Haab and McConnell, 1997). Thus, the spike model is more appropriate.

4. Concluding remarks

The OOHB DC-CV method was used to measure the environmental value of Saeng Island. Moreover, this paper attempted to adjust and apply the spike model suggested by Kriström to modeling OOHB DC-CV data to deal with zero WTP responses. Overall, the survey was successful in eliciting WTP values for the island conservation and management policy. The mean WTP per household obtained using the OOHB spike model was 2,716 Korean won per annum and significant at the 1% level. This information should be used in the decisions as to whether to implement the policy. In addition, in the application reported herein, the OOHB spike model outperformed the conventional OOHB model significantly, dramatically decreasing the standard error of the mean WTP and making the confidence interval fairly tight.

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