

Strategic Effects on Stated Preferences for Public Goods:  
A Theoretical and Experimental Analysis of a Contingent Valuation Survey

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## **ABSTRACT**

This paper analyzes the strategic behavior behind stated preferences in contingent valuation (CV) surveys. CV is one of several methods used to assess the value of environmental goods. It uses survey data in which respondents are asked about their willingness to pay (WTP) or willingness to accept compensation (WTA) for the environmental goods in question. Economic models of dichotomous choice with follow-up open-ended questions are developed. While respondents can report their preferences freely in the open-ended (OE) format, they must make a choice between “yes” or “no” to the offered payment scheme in a dichotomous choice (DC) format. Theoretical analysis shows that truth telling is the optimal strategy for the first DC question, but free-riding is optimal for the follow-up OE question. Furthermore, the strategic downward bias in follow-up responses is affected by the number of players and by the payment offered. We use experimental CV survey data of stated preferences for protecting the landscape of the Kushiro Wetland National Park in Hokkaido, Japan. Experimental results of this CV survey show that the WTP estimated by follow-up OE responses is significantly lower than the WTP estimated by DC responses, and that the payment offered has a positive effect on follow-up OE responses. These empirical results are compatible with results from theoretical analysis

### **Keywords:**

strategic behavior, contingent valuation, incentive compatibility, experimental survey analysis

## 1. INTRODUCTION

Public policy decision-making often requires an evaluation of the demand for public goods, which often have no market price. It is possible to measure preference for public goods by directly asking people to value them, but the preference data from direct questioning may be suspect. People engaged in strategic behavior may overstate or understate their preference for public goods (Samuelson, 1954). Mechanism design theory shows that it is impossible to design an incentive-compatible response format that allows for more than a binary response if no restrictions are placed on individuals' preferences (Gibbard, 1973; Satterthwait, 1975)<sup>1</sup>. Experimental economists have tested for strategic effects in stated preferences for public goods in a laboratory setting. For example, Bohm (1972) compared the strategic effects of willingness to pay for television programs between samples with different incentive schemes and his experimental results show no significant difference. Other experiments are summarized in Ledyard (1995).

In the field of environmental economics, contingent valuation (CV) has traditionally been used to estimate the value of environmental resources (Mitchell and Carson, 1989). CV is one of several environmental valuation methods based on survey data; it asks respondents about their willingness to pay (WTP) or willingness to accept compensation (WTA) for the environmental change in question. There are some differences between CV based on survey data and that based on the laboratory experiments of experimental economics; however, the experimental approach of CV is very similar to experimental economics (Fox *et al.*, 1998; Harrison, 1999).

Some elicitation methods have been developed in CV studies including open-ended, bidding game, payment card, and dichotomous choice questions. While the respondents can report their preferences freely in the open-ended (OE) format, they can only make a choice between "yes" or "no" for the payment offered in the dichotomous choice (DC) format. Hoehn and Randall (1987) showed that the DC format can be incentive compatible under some conditions. Carson *et al.* (1999) summarized incentive structures of elicitation methods in CV. Many previous studies on contingent valuation surveys compared between dichotomous choice (DC) and open-ended (OE) methods. These studies suggest that willingness to pay estimated by the DC method tends to be larger than that by the OE method. Cameron *et al.* (1999) reported that the DC/OE willingness to pay ratio generally seems to range between 1.1 and 5 in previous studies. Previous CV studies of the comparison between DC and OE methods include Sellar *et al.* (1985), Boyle and Bishop (1988), Johnson *et al.* (1990), Walsh *et al.* (1992), Kealy and Turner (1993), Kristrom (1993), McFadden (1994), Boyle *et al.* (1996), Brown *et al.* (1996), Schulze *et al.* (1996), Loomis *et al.* (1997), and Cameron *et al.* (1999).

The purpose of this paper is to analyze the strategic behavior demonstrated in CV survey

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<sup>1</sup> Clarke (1971) and Groves (1973) show an incentive-compatible mechanism with some assumptions on the restriction of individuals' preferences.

data. The incentive structure of dichotomous choice with a follow-up, open-ended (DC+OE) question format is analyzed using theoretical models and experimental studies. Section 2 provides the theoretical models of the DC+OE format. Theoretical analysis will show that the optimal strategy for respondents in the first DC format might be truth-telling, but it leads to free-riding in the follow-up OE question. Furthermore, strategic behavior in follow-up OE responses will be effected by the payment offered in the first DC question. Section 3 describes the experimental design used in the empirical analysis. The target of our CV survey is to analyze the strategic effects in stated preferences for protection of the landscape of the Kushiro Wetland National Park in Hokkaido, Japan. Empirical results are shown in section 4. Finally, section 5 provides concluding comments.

## 2. MODELS

### The government and players

The government needs to know public preferences for public goods. The status quo of the public good is  $Q^0$  and the government has a plan to improve this public good to level  $Q^1$ . The cost of improvement is  $C$ . The government offers a tax,  $T=C/n$ , on  $n$  players, and the government estimates their bids ( $b_i$ ) from players' responses. The government supplies these public goods when aggregate bids are more than the cost ( $\sum_i b_i \geq C$ )

Assume that the utility function of player  $i$  is expressed as  $v_i(Q, M_i)$  where  $M_i$  is the income of player  $i$ , and  $v_i$  is continuous and non-decreasing in  $Q$  and  $M_i$ . True willingness to pay (tWTP) for improving  $Q^0$  to  $Q^1$  is defined by

$$v_i(Q^0, M_i) = v_i(Q^1, M_i - tWTP_i)$$

Player  $i$  considers that other players' bids are distributed as  $b_{-i} = b_{-i}^* + \boldsymbol{\epsilon}$  where  $\boldsymbol{\epsilon}$  is an error term.

Then player  $i$ 's objective probability of approving the improvement of public goods is as follows:

$$\begin{aligned} \Pr[\text{approval}] &= \Pr\left[\sum_i B_i \geq C\right] = \Pr\left[(n-1)b_{-i} + b_i \geq nT\right] \\ &= \Pr\left[\boldsymbol{\epsilon} \geq \frac{nT - b_i}{n-1} - b_{-i}^*\right] = 1 - F\left[\frac{nT - b_i}{n-1} - b_{-i}^*\right] \end{aligned} \quad (1)$$

where  $F$  is the cumulative density function of  $\boldsymbol{\epsilon}$ .

### Dichotomous Choice Format

A single dichotomous choice (DC) question between two alternatives is one of the most commonly used preference elicitation formats in contingent valuation studies. In the DC format, the government offers public policy ( $Q^1, T$ ) and a player's response is only "Yes" or "No". The government calculates a player's bid from the relationship between the suggested tax and the response. When the response is yes, then player  $i$ 's bid calculated by the government is  $b_i(T_i, Y)$ , otherwise it is  $b_i(T_i, N)$ , where  $b_i(T_i, Y) > b_i(T_i, N)$ . Then, from the characteristics of the monotonically increasing cumulative density function ( $F$ )

$$1 - F\left(\frac{nT - b_i(T, Y)}{n-1} - b_{-i}^*\right) \geq 1 - F\left(\frac{nT - b_i(T, N)}{n-1} - b_{-i}^*\right). \quad (2)$$

This means that player  $i$ 's objective probability of policy approval when saying "Yes" is higher than "No".

The bid estimated by the governments may not be equal to the true willingness to pay of a player because of the player's strategic behavior. Assume that the player's response is designed to maximize their expected utility. The expected utility of player  $i$  is

$$Ev_y = v_i(Q^0, m)F\left(\frac{nT - b_i(T, Y)}{n-1} - b_{-i}^*\right) + v_i(Q^1, m - T)\left[1 - F\left(\frac{nT - b_i(T, Y)}{n-1} - b_{-i}^*\right)\right], \quad (3)$$

if the player accepts the suggested tax. If the player rejects it, the expected utility is

$$Ev_n = v_i(Q^0, m)F\left(\frac{nT - b_i(T, N)}{n-1} - b_{-i}^*\right) + v_i(Q^1, m - T)\left[1 - F\left(\frac{nT - b_i(T, N)}{n-1} - b_{-i}^*\right)\right]. \quad (4)$$

Then, player  $i$  says yes when her expected utility of saying yes ( $Ev_y$ ) is higher than of saying no ( $Ev_n$ ). This condition is

$$\begin{aligned} Ev_y - Ev_n &\geq 0 \\ \Leftrightarrow [v_i(Q^1, m - T) - v_i(Q^0, m)] \cdot \left[ F\left(\frac{nT - b_i(T, N)}{n-1} - b_{-i}^*\right) - F\left(\frac{nT - b_i(T, Y)}{n-1} - b_{-i}^*\right) \right] &\geq 0 \\ \Leftrightarrow v_i(Q^1, m - T) - v_i(Q^0, m) &\geq 0 \end{aligned} \quad (5)$$

This means that the player's optimal strategy is truth telling. Player  $i$  says yes when the suggested tax is lower than her WTP, and otherwise says no. Thus, the DC format is incentive compatible. This result is similar to that of Hoehn and Randall (1987).

### Dichotomous Choice with a Follow-up Open-Ended Question

Assume that players are asked their willingness to pay for a policy after a dichotomous choice question. This follow-up question is open-ended (OE): players can report their bids freely. Assume that the payment of player  $i$  is the stated bid,  $b_i$ , rather than the suggested tax,  $T$ . Then, the utility maximization problem of player  $i$  is

$$\text{Max}_{b_i} v_i(Q^0, m) F\left(\frac{nT - b_i}{n-1} - b_{-i}^*\right) + v_i(Q^1, m - b_i) \left[1 - F\left(\frac{nT - b_i}{n-1} - b_{-i}^*\right)\right]. \quad (6)$$

The first order condition is as follows

$$v_i(Q^1, m - b_i) - v_i(Q^0, m) = (F(\cdot) - 1) \cdot \frac{\partial v_i^1}{\partial b_i} \cdot \frac{n-1}{f(\cdot)} \geq 0 \quad (7)$$

where  $f$  is the density function of  $\varepsilon$  and  $\partial v_i^1 / \partial b_i = \partial v_i(Q^1, m - b_i) / \partial b_i$ . This means that player  $i$ 's stated bid is less than her true WTP:  $b_i \leq WTP_i$ . Furthermore, a player's stated bid,  $b_i = b_i(Q^0, Q^1, n, m, T)$ , is effected by the number of players,  $n$ , and the suggested tax,  $T$ . The strength of the strategic effects caused by the number of players and suggested tax depends on the functional form of the utility function and the objective probability function. These results produce the following proposition:

#### Proposition

**In dichotomous choice with a follow-up open-ended question, the first dichotomous choice question is incentive compatible, but strategic players' follow-up bid is less than their true willingness to pay. The follow-up response has a strategic downward bias that is affected by the number of players and the tax suggested in the dichotomous choice question.**

### 3. Experimental Design

The data comes from a contingent valuation survey of the Kushiro Wetland National Park in Hokkaido, Japan. The National Park covers 26,861 hectares and is an important habitat for about 1,400 species of animals, 170 species of birds, 1,150 species of insects, and 600 species of plants. This wetland has been declared internationally significant under the Ramsar Convention of 1980. Over 600,000 people visit the wetland annually, and other recreational resources have been developed around the wetland. For example, 18 golf courses are planned or under development. Some people living in the Kushiro area are concerned about the environmental effects of these recreational resources on animal habitats. Therefore, conflicts have arisen between nature conservationists and resource developers in the Kushiro wetland.

Our objective is to analyze strategic effects in stated preferences for protecting the landscape of the wetland. Two pictures were shown to respondents: the status-quo landscape of the Kushiro wetland and the hypothetical landscape that might result from change due to development around the wetland. The payment vehicle was a voluntary payment to a hypothetical “Wetland Protection Fund”. The description of the payment scheme and hypothetical change in the landscape were as follows:

**Kushiro is rich in environmental resources, but it is difficult to bequeath these resources to future generations. Consider a new fund, the Wetland Protection Fund, which will be established to protect this wetland. Figure 1 shows the landscape of the Kushiro wetland. Assume that this landscape will be changed to Figure 2 by development around the wetland.**

After describing the hypothetical appearance of the landscape, respondents are asked their willingness to pay to protect the wetland landscape. The elicitation method is a dichotomous choice with a follow-up open-ended question (DC+OE).

#### Dichotomous Choice Question

**Would you be willing to pay X yen per year to protect the Kushiro wetland landscape?  
(CIRCLE ONE NUMBER)**

- 1. Yes**
- 2. No**
- 3. I don't have to pay for a fund to protect the environment**

#### Follow-up Open-Ended Question

How much per year would you be willing to pay? (FILL IN THE BLANK)

Yen per year

#### 4. Experimental Results

We conducted a mail-intercept survey on the general public in Sapporo in October 1995. The total sample surveyed was 845. While 81% of the respondents knew of the wetland, only 36% of the respondents had been to the Kushiro wetland. The protest bid was 71. Table 1 shows a description and the mean value of selected variables. For more details of this survey, see Kuriyama (1998).

**Table 1. Descriptive Statistics of the Variables**

Variable Name	Description	Mean Value	Standard Deviation
Age	The age of respondents	29.842	13.528
Know ecosystem	1 = if the respondent knows the word "ecosystem"; 0 = otherwise	0.616	0.487
Landscape	1 = if the respondent indicated that the wetland landscape is important; 0 = otherwise	0.834	0.373
Wilderness	1 = if the respondent knew that wilderness landscape is important; 0 = otherwise	0.852	0.355
Not Residual	1 = if the respondent thought that people cannot live in the wetland; 0 = otherwise	0.463	0.499
LogT	Log of offered payment in the dichotomous choice question	7.627	1.728

Assume that WTP can be expressed as  $\ln WTP_i = \mathbf{b}' \mathbf{x}_i + \eta_i$ , where  $\mathbf{x}_i$  is a vector of regressors and  $\eta_i$  is an error term with mean zero and variance  $\sigma^2$ . Because of the incentive compatibility of the DC format, respondent  $i$  answers 'yes' when  $\ln(T_i) \leq \ln(WTP_i)$ , and answers 'no' when  $\ln(WTP_i) < \ln(T_i)$ . When the error term is assumed to be normally distributed,  $N(0, \sigma_{DC}^2)$ , WTP can be estimated by a probit model, and the probability of a yes response is as follows:



$$\begin{aligned}
\mathbf{p}_i^Y &= \Pr[\ln(T_i) \leq \ln WTP_i] \\
&= \Pr\left[\frac{\ln(T_i) - \mathbf{b}'\mathbf{x}_i}{\mathbf{s}_{DC}} \leq \frac{\mathbf{e}_i}{\mathbf{s}_{DC}}\right] \\
&= 1 - \Phi\left(\frac{\ln(T_i) - \mathbf{b}'\mathbf{x}_i}{\mathbf{s}_{DC}}\right)
\end{aligned} \tag{8}$$

The log likelihood function for the data of DC answers is

$$L_{DC} = \sum_i [d_i^Y \mathbf{p}_i^Y + d_i^N (1 - \mathbf{p}_i^Y)] \tag{9}$$

where  $d_i^Y$  and  $d_i^N$  are dummy variables,  $d_i^Y = 1$  if the response is yes and  $d_i^Y = 0$  otherwise; and  $d_i^N = 1$  if the response is no and  $d_i^N = 0$  otherwise.

It is assumed that the follow-up open-ended (OE) response,  $b_i$ , can be expressed as  $\ln b_i = \mathbf{b}'\mathbf{x}_i + s(n, T) + \boldsymbol{\mu}$  where  $s$  is the strategic effect, which is affected by the number of players and the suggested tax, and  $\boldsymbol{\mu}$  is the normally distributed error term  $N(0, \sigma_{OE}^2)$ . Then the log likelihood function of the follow-up OE question is as follows:

$$L_{OE} = \sum_i \left[ -\frac{1}{2} \ln(2\pi \mathbf{s}_{OE}^2) - \frac{(\ln b_i - \mathbf{b}'\mathbf{x}_i - s(n, T))^2}{2\mathbf{s}_{OE}^2} \right] \tag{10}$$

Then, following Boyle *et al.* (1996), the joint log likelihood function of the DC data and the OE data can be expressed as follows

$$L_{DC+OE}(\mathbf{b}, s, \mathbf{s}_{DC}, \mathbf{s}_{OE}) = L_{DC}(\mathbf{b}, \mathbf{s}_{DC}) + L_{OE}(\mathbf{b}, s, \mathbf{s}_{OE}) \tag{11}$$

For comparison, we analyzed five models. Model 1 uses only DC data, which has no strategic effect. Model 2 uses only follow-up OE data, and assumes no strategic effect ( $s(n, T) = 0$ ). Model 3 uses only follow-up OE data, but it includes strategic bias that is effected by the suggested tax ( $s(n, T) = \mathbf{b}_{\ln T} \ln T$ ). Model 4 uses joint estimation of the dichotomous choice and follow-up open-ended question, and assumes no strategic effect. Model 5 uses joint estimation and includes strategic bias ( $s(n, T) = \mathbf{b}_{\ln T} \ln T + \mathbf{b}_{strategic}$ ).

Table 2 shows the results of estimations under maximization of the likelihood function. AGE indicates the respondent's age, and has a significant positive influence on a respondent's WTP. KNOW ECOSYSTEM is a dummy variable for respondents who know the word "ecosystem".

LANDSCAPE is a dummy variable for respondents who think that the wetland landscape is important. As expected, LANDSCAPE has a positive sign. WILDERNESS is a dummy for respondents who think that wetland wilderness is important. NOT RESIDUAL is a dummy for respondents who think that people cannot live in the wetland, and it has a negative sign.

LOGT is the log of the suggested tax in the OD question. From the theoretical analysis in Section 2, the strategic response in the follow-up question might be affected by the suggested tax. In both model 3 and model 5, LOGT is significant. STRATEGIC is a constant part of the strategic effects (s(n,T)) in the follow-up response and it has negative sign. When the estimated parameters of DC and the follow-up OE data are compared, the likelihood ratio test indicates significant difference between model 1 and model 2 ( $\chi^2 = 12.5$ , significant at  $p < .05$ ).

**Table 2. Estimated Results of the Dichotomous Choice with Follow-up Open-Ended format**

	model 1	model 2	model 3	model 4	model 5
	DC	OE1	OE2	DC+OE1	DC+OE2
CONSTANT	5.178 (11.31)	6.861 (35.83)	4.267 (16.19)	6.695 (37.12)	6.916 (36.11)
AGE	0.033 (3.86)	0.009 (2.33)	0.011 (3.18)	0.013 (3.81)	0.014 (4.54)
KNOW ECOSYSTEM	0.611 (2.62)			0.095 (0.98)	0.125 (1.42)
LANDSCAPE	0.747 (2.36)	0.197 (1.39)	0.235 (1.87)	0.219 (1.69)	0.239 (2.04)
WILDERNESS	0.528 (1.62)	0.240 (1.60)	0.117 (0.88)	0.269 (1.95)	0.151 (1.24)
NOTRESIDUAL		-0.194 (-1.85)	-0.197 (-2.13)	-0.236 (-2.49)	-0.230 (-2.67)
LOGT			0.342 (12.87)		0.343 (12.86)
STRATEGIC					-2.850 (-12.16)
$\sigma_{DC}$	2.095 (13.74)			1.815 (13.84)	1.794 (13.94)
$\sigma_{OE}$		1.610 (17.39)	1.264 (17.39)	1.617 (17.27)	1.266 (17.30)
N	714	605	605	601	601
Log Likelihood	-366.03	-1002.47	-929.25	-1287.75	-1212.72

Table 3 shows the median of the willingness to pay estimated by these models. The numbers in brackets are 95% confidence intervals, which are obtained using the method of Krinsky and Robb (1986), and based on 4,000 random draws. While the WTP of the dichotomous choice question is 2059 yen, the WTP of the follow-up open-ended question is 1649 yen. The WTP in the joint model with strategic effects (model 5) is 2087 yen. This is not significantly different from the WTP of the dichotomous choice data, but it is significantly different from the WTP of the follow-up open-ended data. These results indicate that the WTP estimated by the data of the follow-up

open-ended response is significantly lower than the WTP estimated by the data of the dichotomous choice response, as expected by our theoretical analysis.

**Table 3. Willingness to Pay for the Dichotomous Choice with Follow-Up Open-Ended Data**

Unit: yen / year / household

model 1	DC	2,059	[ 1,650 - 2,557 ]
model 2	OE1	1,649	[ 1,487 - 1,826 ]
model 3	OE2	1,649	[ 1,508 - 1,802 ]
model 4	DC+OE1	1,725	[ 1,576 - 1,891 ]
model 5	DC+OE2	2,087	[ 1,694 - 2,568 ]

NOTE: The numbers in brackets are the 95% confidence intervals, which are obtained by the method of Krinsky and Robb (1986), and based on 4,000 random draws.

## 5. Discussion

We analyzed the strategic effects on stated preferences of dichotomous choice with a follow-up open-ended CV survey. Theoretical analysis shows that strategic players may understate the follow-up open-ended responses, and the effects on follow-up OE response of a suggested payment in DC format can be regarded as strategic behavior. The experimental results of the CV survey data show that WTP estimated by follow-up OE responses is significantly lower than WTP estimated by DC responses, and suggest that payment has positive effects on follow-up OE responses. These empirical results are compatible with the results from theoretical analysis, and strategic effects can be one reason for this difference between the WTP of the DC and of the follow-up OE responses. However, it cannot reject the possibility that the responses of DC may be biased due to other reasons such as “yea saying” (Cooper and Loomis, 1992; Kanninen, 1995). While our analysis focuses on the strategic behavior of the responses in a CV survey, stated preference data can be affected by other sources of bias. Previous CV studies have shown that stated preference in CV survey data includes errors due to bias, including scenario mis-specification, payment vehicle, implied value cues, and so on (Carson, 1991). More experimental tests of the reliability and validity of stated preferences in experimental studies deserve further study.

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