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Abstract

This paper develops a general model that addresses the starting point bias in the dichotomous choice evaluation data by incorporating both the anchoring effect and yea-saying bias. The model is applied to a contingent valuation study that evaluated the health benefits of air quality improvement in three major metropolitan areas in Taiwan. The empirical evidence shows a strong anchoring effect but a weak yea-saying bias. The results show a serious understated willingness to pay if the biases in anchoring and yea-saying are not controlled.

Key words: CVM, double-bounded dichotomous data, starting point bias, anchoring effect, yea-saying bias

I. Introduction

The contingent valuation (CV) method obtains evaluation data on non-market goods and services by inquiring into people's willingness to pay (WTP) or their response to certain hypothetical market scenarios. In order to elicit more reliable answers from respondents, researchers have developed several different methods of asking evaluative questions, for example, open-ended questions, bidding games, payment cards, single-bounded dichotomous choice (closed-ended) questions, and multiple-bounded dichotomous choice questions. Among the methods, the dichotomous choice (DC) dominates in the contingent valuation surveys of non-market goods and services [6]. It is regarded as providing an easier response than open-ended questions, and its follow-up questions, which produce double-bounded dichotomous choices, improve the efficiency of the questionnaires. However, even with these advantages over other methods, the empirical evidence has shown that DC is still subject to the pitfall of bidding games, namely, through starting point bias, which DC questions were supposedly developed to avoid [9, 10, 14, 15, 20, 21].[1]

Several methods have recently been developed in an effort to address the problem of starting point bias in DC questions. Two approaches have been proposed. The first approach addresses the starting point bias by designing better CVM questionnaires and surveys. Alberini [3] demonstrates that overlaid ranges of different bid values and fewer numbers of bid values improve the efficiency of median WTP estimates. Blamey, *et al*. [8] propose a new questionnaire format, referred to as the dissonance-minimizing format, which aimed to elicit respondents' views on CVM questions.

The second approach explicitly models and estimates response incentive effects or biases that might occur in DC valuation data. Alberini, *et al*. [4] propose three different models that would allow for random response shocks, structural shifts in the level of WTP between bid questions, and heteroskedasticity within and between responses. Hadker, *et al*. [13] use bid value as a proxy variable to correct starting point bias in an econometric estimation. Herriges and Shogren [14] model the anchoring effect in the DC data that might result in starting point bias

using a Bayesian approach. Their empirical study indicates a strong anchoring effect that led to overestimation of real WTP. O'Conor, *et al*. [20] concur and obtain significant estimates of the anchoring effect and overestimated WTP using the Herriges and Shogren model.

In the Bayesian approach of the Herriges and Shogren [14] model, respondents provide the interviewer with information on their posterior WTP that represents a weighted average of their prior WTP and the initial bid value introduced by the interviewer. The anchoring weight, that is the weight of the initial bid, measures the extent of the anchoring effect on posterior WTP. Herriges and Shogren's innovative model is useful in estimating the magnitude of anchoring weight and hence the starting point bias. However, the model does not take into consideration of the second starting point bias, namely the 'yea-saying bias'.[2]

The presence of yea-saying bias is well-documented in the sequential DC valuation questions. The yea-saying bias is defined as "the tendency of respondents to agree with questions regardless of the content" [8]. The presence of yea-saying bias may be motivated by the 'warm glow' effect. Becker [7] claims that people have a taste for giving perhaps because of receiving status or acclaim, or simply feeling a 'warm glow' from having 'done their bit.' Andreoni [5] concludes that individuals contribute to a public good for two reasons; they get satisfaction for the public good itself and also have the private benefit of a "warm glow" from their giving. Kahneman and Knetsch [16] find that the CV response reflects an individual's WTP for the moral satisfaction of contributing to public goods, not just the economic value of these goods. The yea-saying bias may also be due to the social pressure faced by respondents during the survey. People are usually sensitive to public opinion in their community. If the public opinion of a community places a high priority on the public spirit that induces good citizens to contribute their share of responsibility to the provision of public goods, then a respondent in the community may have a higher propensity to say 'yes' to CV questions that ask the respondent how much he is willing to pay for the provision of public goods. Thus, in addition to the anchoring effect of bid values that leads to biased responses to DC questions, the yea-saying bias also leads to a biased-

[1] Starting point bias occurs when the initial bid introduced by the interviewer influences the level of WTP of the respondent [8, 14].

[2] Mitchell and Carson [19] said that the anchoring effect and the yea-saying bias are two major sources of starting point bias.

upward response by definition.

Recently, Whitehead [22] developed a model of WTP that incorporates the starting point bias (i.e., anchoring) of Herriges and Shogren [14], and the structural shifts of Alberini, *et al*. [4]. In the Whitehead model, the follow-up questions are incentive-incompatible if the questions induced either an upward or a downward shift of WTP. An upward shift corresponds to yea-saying behavior and a downward shift identifies a nay-saying behavior.[3] Empirically, the incentive incompatibility is modeled as a non-stochastic, fixed effect that is induced by the interviewer in the follow-up question. However, if the existence of the yea-saying or nay-saying behavior is inherent in nature or intrinsic, a self-induced shifting of the WTP at the first valuation question should be apparent and not a response-induced shifting at the follow-up valuation question. Furthermore, since the shift is intrinsic, it will be stochastic and random within individual valuations and across sample respondents.

In this paper, we adopt the model of Herriges and Shogren by incorporating both the anchoring effect and yea-saying bias. The model differs from Whitehead's incentive incompatibility by treating the yea-saying bias as a stochastic, self-induced structural shift of the WTP. In the next section, we present an econometric model and its estimation method. Section III describes the contingent valuation data on the air quality survey from three major metropolitan areas in Taiwan. Section IV compares the results from various model specifications. A brief conclusion is drawn in Section V.

II. An Econometric Model with Stochastic Yea-Saying Bias

While using the CV method to value public goods, researchers assume implicitly that a rational respondent knows his/her latent value for these public goods. In the absence of yea-saying bias, the respondent's latent WTP, denoted as W^*, is assumed to be determined by a vector of the respondent's characteristics X as

[3] Whitehead focuses on the downward shift, i.e., the nay-saying behavior, in the empirical model.

$$W^* = X\,\beta + V \tag{1}$$

where β is the correspondent coefficient vector, and V represents the statistical noise and is symmetric with E(V) = 0.

Since yea-saying bias is defined as the tendency of respondents to agree regardless of the content of the DC questions, we assume that the bias is a self-induced upward shifting of the WTP. Given the respondent's characteristics X, the distribution of WTP is no longer centered at $X\,\beta$ in (1). The prior WTP, W_1, includes a stochastic element of the propensity towards saying 'yes' and is specified as follows:

$$W_1 = W^* + U = X\,\beta + \varepsilon\,, \tag{2}$$

where yea-saying bias, U, is a one-sided, nonnegative random error. The composite error ε = (V+U) does not have a zero mean. The nonnegative error component U reflects the fact that yea-saying propensity will raise a respondent's prior WTP.

Thus, respondent's answers to the first bid question of whether they would be willing to pay b_1 for an improvement of air quality, would be 'yes' if the prior willingness to pay, W_1 was greater than b_1, and the response would be 'no' otherwise. That is:

$$\begin{aligned} d_1 &= 1 \text{ if } W_1 \geq b_1 \text{ or } \varepsilon = V + U \geq b_1 - X\,\beta, \\ &= 0 \text{ if } W_1 < b_1 \text{ or } \varepsilon = V + U < b_1 - X\,\beta, \end{aligned} \tag{3}$$

where d_1 is an indicator variable.

According to Herriges and Shogren [14] model, the presence of an anchoring effect in the follow-up question implies a weighted average of the prior willingness to pay W_1 and the initial bid amount b_1 to form the posterior willingness to pay W_2. That is,

$$W_2 = (1-\gamma)W_1 + \gamma\, b_1\,, \tag{4}$$

where γ is the anchoring weight and $0 \leq \gamma \leq 1$. The respondent's answer to the follow-up question of whether he is willing to pay the bid amount b_2 will be "yes" if W_2 was greater than b_2;

otherwise, the response would be 'no'. That is:

$$\begin{aligned} d_2 &= 1 \text{ if } W_2 \geq b_2 \text{ or } \varepsilon = V + U \geq \frac{b_2 - \gamma b_1}{1-\gamma} - X\beta, \\ &= 0 \text{ if } W_2 < b_2 \text{ or } \varepsilon = V + U < \frac{b_2 - \gamma b_1}{1-\gamma} - X\beta, \end{aligned} \tag{5}$$

It is obvious that the probability of a "yes" response in each valuation question depends on the probability distribution of the composite error ε. Since the stochastic "yea-saying" bias is nonnegative, the distribution of the composite error is positively skew. Under the normality assumption for the symmetric random noise V, the probability is not likely to be estimated by, for example, a probit or logit model.[4]

Assume that the symmetric random error V is normally distributed with zero mean and constant variance σ_v^2, i.e., $N(0, \sigma_v^2)$, and the nonnegative error U is distributed half-normal, i.e., $N^+(0, \sigma_u^2)$. The assumption of nonnegative half normal on the "yea-saying" bias U is based on the plausible proposition that the modal value of the bias is zero, with increasing value of the bias becoming increasingly less likely. It is also based on tractability, since it is relatively easy to derive the distribution of the composite error $\varepsilon = (V+U)$. Under the independent assumption of V and U, Aigner, *et al.* [2] derived the density function of the error term $\varepsilon = U + V$ as

$$f(\varepsilon) = \frac{2}{\sigma}\phi\left(\frac{\varepsilon}{\sigma}\right)\Phi\left(\frac{\lambda\varepsilon}{\sigma}\right), \tag{6}$$

where $\lambda = \sigma_u/\sigma_v$, $\sigma^2 = \sigma_u^2 + \sigma_v^2$, and $\phi(.)$ and $\Phi(.)$ are the standard normal density and distribution functions, respectively. The parameter λ provides a useful indication of the relative contributions of V and U to ε. As $\lambda \to 0$, it implies either $\sigma_u^2 \to 0$ or $\sigma_v^2 \to \infty$, and the symmetric error component of random variation dominates the "yea-saying" bias in the determination of the prior willingness to pay, W_1. In this case, the model reduces to the model of

[4] In the incentive incompatibility model of Whitehead, the "yea-saying" bias U is assumed to be non-stochastic. Thus the estimation of the probability via a probit model is appropriate.

Herriges and Shogren if $U = 0$, and the model becomes the fixed-effect model of Whitehead if the yea-saying bias U is a

non-stochastic constant. Similarly, when $\lambda \to \infty$, it implies either $\sigma_u^2 \to \infty$ or $\sigma_v^2 \to 0$, and the "yea-saying" bias becomes the dominant source of random variation in the determination of the prior willingness to pay, W_1.

This density function (6) is asymmetrically distributed, with mean and variance. The mean 'yea-saying' bias and the variance of the error term ε are given by:

$$E(\varepsilon) = E(U) = \sqrt{\frac{2}{\pi}}\ \sigma_u = \sqrt{\frac{2}{\pi}}\ \frac{\lambda}{\sqrt{1+\lambda^2}}\ \sigma$$
$$\mathrm{Var}(\varepsilon) = \left(\frac{\pi - 2}{\pi}\right)\sigma_u^2 + \sigma_v^2 = \left(1 + \frac{(\pi - 2)\,\lambda^2}{\pi}\right)\frac{\sigma^2}{1+\lambda^2} \quad . \tag{7}$$

Using the density function (6), the log likelihood function of the model for a sample of n respondents is:

$$\ln L = \sum_{\substack{d_1=1\\ d_2=1}} (\ln P_{11}) + \sum_{\substack{d_1=1\\ d_2=0}} (\ln P_{10}) + \sum_{\substack{d_1=0\\ d_2=1}} (\ln P_{01}) + \sum_{\substack{d_1=0\\ d_2=0}} (\ln P_{00}), \tag{8}$$

where

$$P_{11} = \text{Prob}\,(d_1 = 1, d_2 = 1) = 2\int_{a_1}^{\infty} \phi(t)\,\Phi(\lambda t)\,dt,$$
$$P_{10} = \text{Prob}\,(d_1 = 1, d_2 = 0) = 2\int_{a_2}^{a_1} \phi(t)\,\Phi(\lambda t)\,dt,$$
$$P_{01} = \text{Prob}\,(d_1 = 0, d_2 = 1) = 2\int_{a_1}^{a_2} \phi(t)\,\Phi(\lambda t)\,dt,$$
$$P_{00} = \text{Prob}\,(d_1 = 0, d_2 = 0) = 2\int_{0}^{a_1} \phi(t)\,\Phi(\lambda t)\,dt,$$

and

$$a_1 = \frac{b_2 - \gamma b_1}{\sigma(1-\gamma)} - \frac{XB}{\sigma}; \qquad a_2 = \frac{b_1 - XB}{\sigma}.$$

P_{11}, P_{10}, P_{01} and P_{00} are the probabilities for the four possibilities of observations based on the answers to the two bid questions. For $d_1 = 1$, it implies that $W_1 > b_1$ and the response to the first

bit value b_1 is "yes". In this case, the second bid value b_2 is then raised and $b_2 > b_1$. Thus the probabilities, P_{11} and P_{10}, are evaluated only for observations that $b_2 > b_1$. Similarly, for $d_1 = 0$, it means that $W_1 < b_1$ and with the response "no" to the first bit value b_1. The second bid value b_2 is lower. Thus the probabilities, P_{01} and P_{00}, are evaluated only for observations that $b_2 < b_1$.

In addition to the above model that takes into consideration two sources of starting point bias and Herriges and Shogren [14] model of the anchoring effect, we also estimate the model without controlling for the yea-saying bias and the anchoring effect. The willingness to pay latent variable W^* is specified in (1). The log likelihood function is a special case of (8):

$$\begin{aligned} \ln L = & \sum_{\substack{d_1=1 \\ d_2=1}} \ln\left[1-\Phi\left(\frac{b_2 - X\beta}{\sigma_v}\right)\right] + \sum_{\substack{d_1=1 \\ d_2=0}} \ln\left[\Phi\left(\frac{b_2 - X\beta}{\sigma_v}\right) - \Phi\left(\frac{b_1 - X\beta}{\sigma_v}\right)\right] \\ & + \sum_{\substack{d_1=0 \\ d_2=1}} \ln\left[\Phi\left(\frac{b_1 - X\beta}{\sigma_v}\right) - \Phi\left(\frac{b_2 - X\beta}{\sigma_v}\right)\right] + \sum_{\substack{d_1=0 \\ d_2=0}} \ln\left[\Phi\left(\frac{b_2 - X\beta}{\sigma_v}\right)\right]. \end{aligned} \tag{9}$$

III. A Brief Description of the Sample Design and Data

An econometric model with stochastic yea-saying bias is illustrated with a CVM study that estimates the willingness to pay on health benefits of air quality improvement from three major metropolitan areas in Taiwan.[5] These areas comprise the cities and counties of Taipei, Taichung, and Kaoshiung (TTK), and have about 10 million residents. In early 1996, we conducted an in-person interview survey of 938 residents age 20 years and over within the TTK areas.[6] The survey was undertaken by the Center for Survey Research at Academia Sinica, and all respondents in the formal survey were randomly sampled.[7] A few outlier observations from

[5] To help in evaluating the effects of air quality, respondents are briefed on the air quality index and its relation to health benefits. Respondents are then asked to value four types of air quality improvements: visibility, health, cleanliness, and erosion reduction. Only the data related to health are used in this empirical study.

[6] The Center for Survey Research at Academia Sinica conducted the interview survey and random sampling of 1,000 residents within the TTK. The survey period extended from January 22nd to February 15th. The high response rate of 93.8% was expected because the interview survey was conducted at each respondent's home.

[7] The sampling method adopted a three-level stratified sampling: first, a random sample of districts from each area, followed by sampling of villages from each sampled district, and lastly, random sampling of individuals from each village. The sample sizes in each stratum were proportional to the population distribution, and each individual had the same possibility to be sampled out.

protest bids and incomplete responses are omitted from the study. The effective sample of 603 observations is used in the model estimation.

The questionnaire in general, and the bid values, payment vehicle employed, and the CVM questions in particular, were carefully designed and tested in one focus group session.[8] One pre-test trial experiment before conducting the formal survey was conducted.[9] All respondents in the focus group and pre-test were randomly selected.

To provide a better picture of how air quality might affect health, two sets of written information on cards are provided to respondents before the CV questions are given to them. The first set of information card lists degrees of potential impacts on health and on activity from five different air quality levels - good, common, bad, very bad, and noxious - expressed in the Pollution Standard Index (PSI) (refer to Table I). The five air quality levels and PSI were chosen because people are generally quite familiar with them from daily radio and TV announcements in Taiwan. The second set of information in card lists the number of days of PSI readings in TTK areas in 1995 (refer to Table II).

Each respondent is asked to value two CVM questions: the willingness to pay for air quality improvement from 'unhealthy' to 'moderate'; and similarly, from 'moderate' to 'good'. The specific CVM question is as follows:

> "*In order to improve the air quality of your city such that all of the unhealthy (moderate) air quality days in 1995 become moderate (good), are you willing to pay NT$_____ annually for the government and firms to control air pollution*?"

We explained to each respondent the payment vehicle in the following sentence:

> *"Although you do not actually pay the money you indicated in the CVM*

[8] The focus group discussion was held on December 30th in 1995, and the randomly sampled 10 discussants cover different genders (5 males, 5 females), professions (taxi driver, housewife, technician, noodle shop employer, owner of small business, car mechanics, computer programmer, and so on.), education levels (university, college, junior and senior high-school, professional high school) and ages (26 to 50 years old).

questions, improving air quality will increase the government budget and firms' air pollution control cost. Consequently, you in fact pay them through higher taxes and higher prices in general. Therefore, please answer the CVM questions carefully."[10]

The respondents were randomly assigned a set of three bid values from a list of ten given in Table III. The first bid value in each set is the starting WTP bid for the first question. In the follow-up question, the respondents are offered a second bid value twice the first starting value if the answer to the first question is a 'yes'. If the first answer is a 'no', the second bid value is half the first bid value. The design and the ranges of the ten bid value sets are determined and tested from the focus group discussion and the pre-test survey.

In this study we also allow the respondents to define the health effect of the air quality in their own residence area in a five-scale Likert-type question.[11] "*To what extent do you believe that the air quality in your residence area could affect your health in the future?*" The question allows us to use residents' own perceptions of air quality to model their evaluative behavior.[12]

Table IV provides statistics of the sample and its population. We find sample respondents have a significantly higher male proportion and education level, and are younger. However, there is no significant difference in income.

IV. Empirical Results

We assume that the underlying willingness to pay function is the logarithmic function,

$$\ln W^* = X\beta + V\,, \tag{10}$$

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[9] Fifteen pre-test interviews were completed during January 5th-8th in 1996. 7 respondents are male, and 8 are female; age is between 25 to 69 years old.

[10] During the focus group discussion session, we presented three kinds of payment vehicles: decreasing the government budget on items other than air quality improvement, donating money to government foundations devoted to improving air quality, and higher taxes and higher prices in general. The majority of the focus group discussants chose the third payment vehicle.

[11] The Likert-type five scales are: 'not at all', 'a little', 'somewhat', 'a lot', 'very much'.

[12] Adamowicz, *et al.* [1] found that a combination of the stated and revealed behavior model, based on perceptions, slightly outperformed that models based on objective attribute measures.

The vector of the independent variables X is defined and given in Table V. The logarithmic prior willingness to pay, W_1, with yea-saying bias, U, is

$$\ln W_1 = X\,\beta + V + U\,. \tag{11}$$

The two bid values, b_1 and b_2, are also in logarithmic form. The two error terms V and U are assumed to be independent with the symmetric error V normally distributed, $N(0,\ \sigma_v^2)$, and the nonnegative error U half-normal, i.e., $N^{+}(0,\ \sigma_u^2)$. Since W^* and W_1 are expressed in logarithmic form, we have the expectation, $\mathrm{E}(W_1) = \mathrm{E}(W^*)\ \mathrm{E}(e^U)$. The expected value of the 'yea-saying' bias [17] thus becomes:

$$E\left(e^U\right) = 2\exp\left(\sigma_u^2\right)\Phi\left(\sigma_u\right) = 2\exp\left[\frac{\lambda^2\sigma^2}{2\left(1+\lambda^2\right)}\right]\Phi\left[\frac{\lambda\sigma}{\sqrt{1+\lambda^2}}\right]. \tag{12}$$

Table VI presents the maximum likelihood estimates of four different model specifications. Models I and II are specifications without controlling for the yea-saying bias and the anchoring effect. The log likelihood function is given in (9). To test the existence of a starting point bias, Model II includes additional nine dummy variables to identify various sets of bid values. The fifth set of bid values is selected as the reference set. The dummy variables are identified in ascending order of the first bid value. Model III is the Herriges and Shogren model with an anchoring effect. Model IV is the new model with both the anchoring effect and the self-induced random yea-saying bias.

As expected from Table VI, Model I shows that higher income (Ln(INC)) individuals, frequent outdoor activists (OUTDOOR), and volunteers in environmental organization (EPT), are willing to pay more to improve air quality for the sake of their health. The results also confirm that individuals having more vulnerable family members (VULNERABLE), exposed to air pollution (EXPOSURE) in the workplace, in school and at home, and having respiratory symptoms (RESPIRATORY), are willing to pay more for cleaner air. It is somewhat unexpected that older individuals (AGE) and those who stay outside longer hours (OUTIME) are willing to pay less. Geographically, individuals who live in Taichung City (CITY2) where the air quality is generally better are willing to pay less for further improvement than those who live in Kaoshiung

City.

There are few differences in results on the estimates between Model I and II, except in respect to the coefficients on AGE and ASTHMA. However, Model II clearly shows that starting point bias in bid values. Of the nine dummy variables for the bid values, all but the two are statistically significant. The coefficient estimates are negative for the dummies D1 – D4 and are positive for the dummies D6 – D10. Since the dummy variables are identified in ascending order of the first bid value, the estimates clearly show a positive correlation with the bid values. This implies that the responses to DC questions are clearly influenced by the first bid values introduced by interviewers. It is noteworthy that the coefficient estimates of QUESTION in Model I and II are all negatively significant. This outcome seems to contradict the prior belief that marginal willingness to pay would decline as air quality improves.

Model III extends Model I by including the anchoring effect in the DC evaluation. The signs of those statistically significant estimates do not differ between the two models. However, there are significant disparities in magnitude of the estimates. In particular, the coefficient of the variable QUESTION in Model III becomes positive and statistically significant. This result implies that marginal willingness to pay declines as air quality improves. Most significantly, however, Model III strongly identifies the anchoring effect with the estimated anchoring weight γ, which is significantly larger than zero.[13]

Model IV shows the empirical findings from the specification that includes both sources of starting point bias, anchoring effect and yea-saying bias. As in Model III, a significant anchoring effect is also observed. However, a small positive and statistically insignificant estimate of the yea-saying bias λ is seen as well. Using (12), the estimate of $E(e^{U}) = 1.0146$, indicates that, on average, the yea-saying bias accounts for only 1.46% of the average latent willingness to pay, $E(W^*)$. In terms of monetary value, there are about NT$72 for the improvement in air quality from worse to moderate, and about $45 for the improvements from moderate to good (refer to Table VII).

[13] Since the latent WTP is in logarithmic form, the posterior WTP in the follow-up valuation is the geometric mean, $W_2 = W_1^{1-\gamma}\ b_1^{\gamma}$. Thus γ is the geometric weight.

The rest of the coefficient estimates in Model IV does not differ much from Model III. The findings show that the WTP depends positively and significantly on income (Ln(INC)), the number of vulnerable families (VULNERABLE), outdoor activities (OUTDOOR), respiratory symptoms (RESPIRATORY), and improvement level of air quality (QUESTION). The WTP is negatively relates to aged (AGE), stay outsides longer hours (OUTIME), suffer from asthma (ASTHMA), live in Taichung City (CITY2).

Table VII summarizes the estimates of the latent willingness to pay $E(W^*) = X\beta$ from the four model specifications. The summary shows that the estimates of the mean and median of the latent WTP in Model III and IV controlling for the biases in anchoring and yea-saying are two to five times greater than the estimates in Model I and II without controlling for the biases. This finding is contrary to other empirical studies [12, 14, 20] where the mean and median of the prior WTP is higher when anchoring is not accounted for. One possible explanation of the causes of this understated WTP when the anchoring and yea-saying biases are not controlled for may be due to the lower starting bid values used in the survey (see Table III). This result is consistent with the estimate that survey respondents are heavily anchoring ($\gamma = 0.64$) to the lower starting bid values.

V. Conclusions

In this study, we develop an extended model on starting point bias that takes into consideration two sources of the bias, the anchoring effect and the yea-saying bias, in the context of double-bounded DC CVM surveys. The two biases are distinct in that the anchoring effect is related to bid values and the yea-saying bias is a self-induced shifting of the WTP. The extended model is applied to measure the willingness to pay for air quality improvement in three major metropolitan areas in Taiwan. We found a strong anchoring effect on the valuation of the air quality, and a weak yea-saying bias. The significant anchoring effect is consistent with other empirical studies. This insignificant yea-saying bias may be due to the fact that improving air quality is usually seen as mainly the responsibility of polluters and governments, not of ordinary citizens in Taiwan. Thus, the respondents' tendency to agree with CV questions would be less. Chien [11] found that the warm glow effect is very strong in Californians' WTP for preserving grey whales. We expect that, for good causes such as symbolic wildlife, the warm glow effect

would be stronger and, consequently, the yea-saying bias more significant.

Table I. Health Impact of Different Air Quality Levels Expressed in the Pollution Standard Index (PSI)

Air Quality Levels	PSI Readings	Health impact	Activities restricted
Good	0-50	None	None
Moderate	51-100	Eye irritation	Few persons affected
Unhealthy	101-199	Eye irritation Breathing problems	Some persons affected
Very unhealthy	200-299	Eye irritation Breathing problems Coughing Headaches Reduced alertness	Most persons affected Children, elderly, and persons with lung or heart diseases should stay indoors and reduce physical activity
Hazardous	>299	Eye irritation Breathing problems Coughing Headaches Reduced alertness Nausea Possible premature death for the chronically ill	Most persons affected Children, elderly, and persons with lung or heart diseases should stay indoors and reduce physical activity General population should avoid outdoor activity

Source: Loehman *et al*. [18].

Table II. Air Quality in the Taipei, Taichung and Kaoshiung Areas in 1995

Unit: Percentage of measurement days

Air Quality Levels	PSI readings	Cities & Counties		
		Taipei	Taichung	Kaoshiung
Good	0-50	48%	31%	21%
Moderate	51-100	48%	66%	64%
Unhealthy	101-199	4%	3%	15%
Very unhealthy	200-299	0	0	0
Hazardous	>299	0	0	0

Source: *Yearbook of Environmental Protection Statistics, Taiwan, Republic of China, 1995.*

Table III. Ten Bid-Value Sets and Bid Responses for Air Quality Improvements in the CVM Questionnaire

Bid-value Sets		Air Quality Improvements								
		Unhealthy to Moderate								
		Obser-vations	yy	Yn	ny	nn	yy%	yn%	ny%	nn%
Set 1	(20,40,10)	50	42	4	1	3	84.0	8.0	2.0	6.0
Set 2	(40,80,20)	60	45	5	1	9	75.0	8.3	1.7	15
Set 3	(80,160,40)	62	36	17	1	8	58.0	27.4	1.6	12.9
Set 4	(120,240,60)	66	43	9	2	12	65.2	13.6	3.0	18.2
Set 5	(200,400,100)	66	39	13	3	11	59.1	19.7	4.6	16.7
Set 6	(300,600,150)	56	21	18	5	12	37.5	32.2	8.9	21.4
Set 7	(450,900,225)	57	24	16	4	13	42.1	28.1	7.0	22.8
Set 8	(650,1300,325)	63	31	20	4	8	49.2	31.8	6.4	12.7
Set 9	(900,1800,450)	57	28	19	3	7	49.1	33.3	5.3	12.3
Set 10	(1200,2400,600)	66	28	14	6	18	42.4	21.21	9.1	27.3
		Moderate to Good								
Set 1	(50,100,25)	50	34	12	0	4	68.0	24.0	0.0	8.0
Set 2	(100,200,50)	60	40	8	2	10	66.7	13.3	3.3	16.7
Set 3	(200,400,100)	62	31	14	5	12	50.0	22.6	8.1	19.3
Set 4	(300,600,150)	66	32	16	5	13	48.5	24.2	75.6	19.7
Set 5	(500,1000,250)	66	28	17	5	16	42.4	25.8	7.6	24.2
Set 6	(800,1600,400)	56	11	19	11	15	19.6	33.9	19.6	26.8
Set 7	(1200,2400,600)	57	18	11	12	16	31.6	19.3	21.0	28.1
Set 8	(1600,3200,800)	63	20	21	11	11	31.7	33.3	17.5	17.5
Set 9	(2000,4000,1200)	57	16	20	8	13	28.1	35.1	14.0	22.8
Set 10	(3000,6000,1500)	66	11	22	10	23	16.7	33.3	15.2	34.8

Notes:

a. The first number in parentheses is the starting WTP bid value (b_1). If the answer to the first question is 'yes', the second value is asked; if the answer is 'no', the third value is asked.

b. The design of the ten bid-value set in the CV questions is in accordance with the responses to open-ended questions in one pre-test interview survey and one focus group discussion.

Table IV. Descriptive Statistics of the Sample and 1995 Population

	Sample	1995 Population *
Persons over 20 years old	603	7,134,770 *
Gender: Male	57.2%	50.6%
Female	42.8%	49.5%
Average age (years)	39.02	44.7
Education levels		
Primary school and under	22.6%	37.9%
Junior high school	12.4%	11.6%
Senior high school	30.5%	28.4%
Universities	31.5%	18.9%
Graduate school and over	3.0%	3.2%
Working status		
Employed	89.7%	
Retired	1.2%	
Unemployed	0.2%	
Students	3.6 %	
Household management	2.0%	
Others	3.3%	
Average numbers of household members	4.72	
Monthly personal income (NT$)	37,098	39,291
Annual household income (NT$)	828,559	801,001

Notes: * The total population in the TTK area is about 10,000,000. The descriptive statistics of the population are from *The Census of the Republic of China, 1994* and *Statistical Abstract of National Income, Taiwan Area, Republic of China, 1951-2000*.

Table V. Definition of Variables

Variables	Definition
EDU	Education level (1 = primary school and under, 2 = junior high school, 3 = senior high school, 4 = university, 5 = graduate school and above)
Ln(INC)	Natural log of average monthly personal income (NT$)
RISK PERCEPTION	An index from 1 to 5 that measures respondents' of health risk perception (1= no risk, 5 = very high risk)
VULNERABLE	Numbers of household members who are over 65 years old or under 12 years old
OUTIME	The time spent outside in a day
OUTDOOR	Numbers of domestic and overseas trips in 1995
EXPOSURE	Measure of exposure to air pollution at work, school or home (= 1, if yes; = 0 otherwise)
SEX	Gender (1 = male, 2 = female)
AGE	Age
DEFENSE	An index from 0 to 1 that measures the degree of a respondent's defense behaviors to air pollution, including wearing mask, moving to clear residential area, installing air conditioner, air purifier, or dehumidifier, keeping exercise to maintain healthy, and so on
EPT	An index of ever participating or being volunteer workers in environmental organizations (1 = yes, 0 = no)
RESPIRATORY	An index from 0 to 9 that measures the frequency and seriousness of acute respiratory symptoms in a year before the survey, such as nose-watering, snot, allergy, bronchitis, tachypnoea, coughing, sputum, sore throat, and so on
FEVER	An index from 0 to 9 that measures the frequency and seriousness of fever-related symptoms in the year prior to the survey, such as fever, headache, muscle pain, nausea, and so on
ASTHMA	An index from 0 to 9 that measures the frequency and seriousness of asthma in the year prior to the survey
SKIN	An index from 0 to 9 that measures the frequency and seriousness of skin-related symptoms in the year prior to the survey, such as itching, eruption, and so on
EYE	An index from 0 to 9 that measures the frequency and seriousness of eye-related symptoms in the year prior to the survey, such as itching, watering, excretion, discomfort with contact lens, and so on
QUESTION	= 1 answer to the DC question of improving all the unhealthy air quality days in 1995 to moderate = 0 answer to the DC question of improving all the moderate air quality days in 1995 to good

CITY1	= 1 if respondents reside in Taipei; = 0 otherwise
CITY2	= 1 if respondents reside in Taichung; = 0 otherwise
Dn	Nine dummy variables to distinguish the ten groups of observations facing different sets of bid values, n = 1- 4, 6-10 (n = 5 is the reference bid)
SIGMA (σ)	The scale parameter
GAMMA (γ)	The parameter of anchoring bias
LAMDA (λ)	The parameter of yea-saying bias

Table VI. Parameter Estimates for Air Quality Improvments[a]

Independent Variables	Model I (no control for anchoring effect and yea-saying bias)		Model II		Model III (Herriges & Shrogen, controlling for anchoring effect)		Model IV (controlling anchoring effect and yea-saying bias)	
	Estimates	t-statistics[a]	Estimates	t-statistics	Estimates	t-statistics	Estimates	t-statistics
EDU	0.0587	0.79	0.0272	0.54	0.0997	0.75	0.0790	0.59
Ln(INC)	0.4982	6.48***	0.4086	8.01***	0.5894	4.23***	0.6093	3.00***
RISK PERCEPTION	0.0362	0.59	0.0385	0.93	0.0608	0.54	0.0727	0.64
VULNERABLE	0.1334	2.40 ***	0.0667	1.80*	0.1855	1.88*	0.1765	1.77*
OUTIME	-0.0485	-1.78*	-0.0204	-1.09	-0.0891	-1.73*	-0.0875	-1.68*
OUTDOOR	0.0165	2.10 **	0.0114	2.23**	0.0346	2.48***	0.0347	2.46***
EXPOSURE	0.4508	1.82 *	0.3331	1.90*	0.4621	0.99	0.4402	0.93
SEX	0.0049	0.03	0.0735	0.74	-0.3005	-1.09	-0.2956	-1.00
AGE	-0.1423	-2.18**	-0.0604	-1.37	-0.2890	-2.36***	-0.3173	-2.50***
DEFENSE	0.0691	0.48	0.0857	0.92	0.0433	0.18	0.0472	0.19
EPT	0.7966	2.43***	0.9376	4.18***	1.0317	1.72*	0.9838	1.34
RESPIRATORY	0.1007	2.02 **	0.0737	2.20**	0.1578	1.77*	0.1562	1.74*
FEVER	-0.0379	-0.47	-0.0157	-0.29	-0.0377	-0.26	-0.0392	-0.26
ASTHMA	-0.0734	-1.21	-0.0871	-2.14**	-0.2013	-1.88*	-0.1974	-1.82*
SKIN	-0.0650	-1.51	-0.0489	-1.60	-0.1244	-1.56	-0.1233	-1.53
EYE	-0.0168	-0.51	-0.0054	-0.23	-0.0197	-0.32	-0.0187	-0.30
QUESTION	-0.2486	-1.84 *	-0.4261	-4.63 ***	0.4526	1.63†	0.4630	1.63†
CITY1	-0.1521	-0.87	-0.0898	-0.75	-0.1417	-0.44	-0.1084	-0.34
CITY2	-0.5132	-2.44 ***	-0.3088	-2.14 **	-0.8430	-2.13**	-0.8056	-2.03**
SIGMA (σ)	1.9616	27.23***	1.3521	24.24 ***	3.6900	9.77***	3.7194	9.53***
GAMMA (γ)					0.6401	16.34***	0.6436	16.07***
LAMDA (λ)							0.0049	0.01
D1			-1.2022	-5.23***				
D2			-0.8799	-4.38***				
D3			-0.6458	-3.29***				
D4			-0.2460	-1.31				
D6			0.0818	0.40				
D7			0.4533	2.28**				
D8			1.0628	5.36***				
D9			1.3366	6.50***				
D10			1.1948	6.36***				
Number of observations[b]	1,206		1,206		1,206		1,206	
Log-likelihood	-1,216.49		-1,133.53		-1,138.43		-1,411.66	

Notes:

a * denotes significant at 10% level; ** at 5% level; and *** at 1% level; † denotes nearly significant at 10% level

b The number of observations of the regression is twice the sample size since we pool two DC questions together. The two questions are distinguished by a dummy variable (QUESTION).

Table VII. Estimates of Latent WTP (*W**)

Unit: NT$

W*	Model I	Model II	Model III	Model IV
	(no control for anchoring effect and yea-saying bias)		(Herriges & Shrogen, controlling for anchoring effect)	(controlling for anchoring effect and yea-saying bias)
Air quality improvement from worse to moderate				
Mean *W**	999	848	4,912	4,958
(standard deviation)	(698)	(809)	(6,126)	(6,200)
Median *W**	817	533	2,951	3,010
Yea-Saying Bias	---	---		72[a]
Air quality improvement from moderate to good				
Mean *W**	1,281	1,298	3,124	3,120
(standard deviation)	(895)	(1,239)	(3,896)	(3,902)
Median *W**	1,048	816	1,877	1,894
Yea-Saying Bias	---	---		45[a]

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