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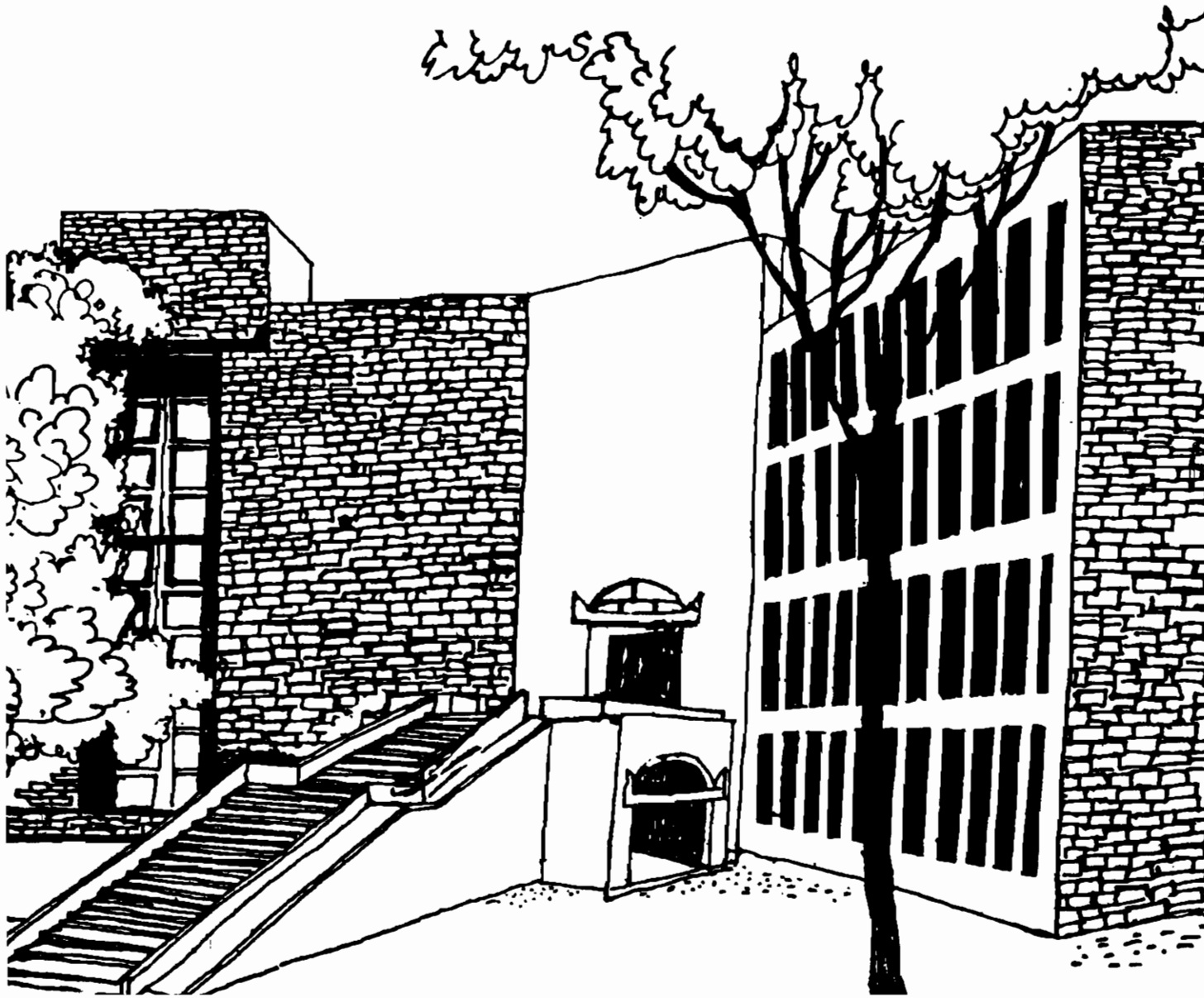

ESTIMATING THE WILLINGNESS TO PAY FOR VETERINARY SERVICES IN INDIA: A METHODOLOGY PAPER

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Estimating the Willingness to Pay for Veterinary Services in India: A Methodology Paper

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The World Bank

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Introduction

Public provision of agricultural support services has been an important component of agricultural development strategy in India. A number of these services have been delivered to the farmers for free or with substantial subsidies. Over the last decade or so, however, serious doubts have been expressed over the sustainability and desirability of this model. Lack of public funds for sustaining the vast delivery infrastructure as well as poor record of government in managing public programs has refocused attention on ways of making these services more cost effective and for improving the quality of these services.

Introduction of some degree of commercialization is one way of improving the service quality (Ahuja and Punjabi, 1999a and 1999b). Cost recovery, it is argued, can build client focus and accountability in the delivery of public services. At the same time, however, serious concerns prevail in India about the distributional consequences of full cost recovery or of private sector participation in the delivery of these services. The debate has centred around farmers' willingness to pay for these services and the possible adverse impact of commercialization on poor farmers. Although these are empirical issues, the empirical studies pertaining to willingness to pay and distributional consequences of commercialization of agricultural services in India are rare.

In response to these concerns, the World Bank, in collaboration with Indian Institute of Management, Ahmedabad and the Swiss Agency for Development and Co-operation, initiated a study to investigate these issues taking the delivery of animal health and breeding

services, as the starting point[1]. This paper describes the survey design and the analytical framework used for estimating the willingness to pay for veterinary services.

Estimating Willingness to Pay

There are two approaches to assessing willingness to pay. One is to exploit observations on prices and quantities currently consumed to estimate demand curves, and from there infer willingness to pay. The second approach is contingent valuation, a more direct assessment of preferences. This approach uses responses to hypothetical questions to infer preferences and willingness to pay. For the purpose of estimating willingness to pay for veterinary services, a household survey and a contingent valuation survey was implemented. The survey covered about 1200 households located in 75 villages in the states of Kerala, Gujarat, and Rajasthan.

The contingent valuation survey

The essence of the contingent valuation approach is the recovery of preferences from responses to hypothetical questions. For the purpose of this study, a dichotomous choice contingent valuation survey was implemented in the referendum framework. In this approach, the respondents is required to answer 'yes' or 'no' to a single payment question (see Box 1 for an explanation of alternative approaches of eliciting willingness to pay). Before presenting the methodology for analyzing the CV responses, however, we present a brief review of the issues in the design and administration of contingent valuation survey.

[1] The study is being co-ordinated at the Center for Management in Agriculture (CMA), Indian Institute of Management, Ahmedabad (IIMA). The work on the study has proceeded in two phases. Phase I focused on understanding and documenting the current status of these services as extensively as possible. Findings from Phase I were discussed in a workshop held at IIMA in October 1998. The rapporteur's report as well as the papers presented in the workshop have been summarized in a separate volume (see Ahuja, 1999)

Issues in Survey Design and Administration

As indicated before, this method relies on describing a hypothetical situation to a sample of individuals and asking them to state their willingness to pay avoid a particular change in that situation, or willingness to accept compensation for the change. In its simplest form, CV asks individuals directly their willingness to pay for having access to a particular level or quality of a goods and services, or to prevent a change in the provision or quality of the service. This is perhaps the only technique for eliciting information about individuals' preferences for goods and services that are not traded in the market.

Superficially, it appears straightforward, even trivial, to ask how much the people will be willing to pay for a good or service. Years of experience with inexpertly designed questions have demonstrated that poor questions can greatly increase the imprecision of measures of willingness to pay. This directness is elusive however. Serious CV researchers spend enormous time and resources in designing the survey. This section, therefore, presents a brief review of the issues in survey design and administration.

Typical applications of CV surveys include following components

1. an introduction for setting the general context of the problem,
2. a description of the good or service being valued,
3. the institutional structure within which the good or the service is to be provided,
4. a credible payment mechanism,
5. a method which seeks to elicit information about respondent's preferences (see Box 1 for a comparison of different approaches of eliciting willingness to pay),
6. a set of follow-up questions to ascertain why the respondents answered the way they did, and
7. information on respondent characteristics, attitudes, and other demographic variables.

Careful design of each of these components and continuous survey monitoring is the heart of any contingent valuation study. Lack of adequate attention at the time of survey design can lead to significantly biased welfare estimates. Previous work has identified a number of different factors that can bias the willingness to pay estimates. These are discussed below. These biases are categorized in many different ways in the literature. The following biases give the flavor of problems that arise.

Information bias: Since contingent valuation has often dealt with non-market goods and services, the respondents are not always adequately familiar with the good or the service being valued. But, for them to be able to provide well informed responses it is important that they understand the implication of the change being proposed. Poor understanding of the good can lead to what has come to be known as the information bias. This bias may not always be true bias, but rather much greater imprecision of estimates. In the CV survey therefore, it is important that careful attention is given to providing respondents with adequate information. The specific wording of the questions (using neutral language as much as possible) also needs to be carefully designed and tested.

Payment vehicle bias: The payment mechanism through which the respondent would be required to pay must be credible. That is, the respondent must believe that they actually would have to pay for the good and that if they do not pay they will not receive the good or the service in question. A classic example of payment vehicle bias occurs with the use of taxes as a vehicle. On occasion, researchers would ask respondents what they would pay in the form of additional taxes. In many settings the inclination to avoid paying taxes is so great,

independent of the service provided, that respondents answer 'no' much more frequently. If there is disbelief on the part of respondents that the payment will actually be extracted using the payment mechanism being described to them at the time of the survey or if the there is uncertainty about whether the money extracted will actually be allocated to the specific project being evaluated, the respondents may not reveal their true willingness to pay.

Hypothetical bias: To ensure the respondent does not provide lightly considered responses,

BOX 1: Methods of eliciting willingness to pay in CV surveys: A brief comparison

There are a number of approaches for eliciting empirical content concerning willingness to pay using contingent valuation. The four most common approaches are the open-ended question, the payment card, the bidding game, and the discrete choice or closed ended approach. Each of these has its virtues, but researchers have settled on the discrete choice approach because its strengths outweigh its weaknesses. More recent methods from marketing practices, such as conjoint analysis, in effect extend the dichotomous choice approach to a multivariate choice.

The open ended approach: In the approach, very simply, the respondent is asked 'the maximum amount he would pay for the service' rather than go without it. This approach has several drawbacks. The vehicle, that is the way in which the money would actually be paid, is harder to identify in this setting, because what is really being asked of the respondent is the reduction in income that he would accept. More practical problems arise from extreme responses that are induced by the open-ended nature of the questions. Sometimes respondents give very high and not credible responses to questions, and other times they respond zero or with protests. In the absence of a clear way to eliminate responses that are not representative of preferences, open-ended questions have been abandoned.

The payment cards: In this approach, the respondent is shown a card that depicts a variety of payments, and asked which he would pay. This approach has been shown to be quite sensitive to the payments on the cards, so that responses can be said to be influenced by anchoring, in the sense that a different set of payments on the card might result in a different willingness to pay.

Bidding games: The respondent is asked if he would pay a given amount, with a no followed by a lower amount and a yes followed by a higher amount, until the true value seems to have been squeezed out. This approach has proved to be susceptible to strategic answers, as respondents begin to see the pattern of questions. The strategic responses can be uncovered by estimating a discrete choice model for each question, and testing whether there is a structural shift in the model as additional payments are addressed to the respondent. Evidence suggests that bidding games induces strategic behavior by the respondent.

Dichotomous choice payments: In this approach, the respondent is given a single payment, and answers with a yes or no. The yes-no responses are then used, along with the required payment, to estimate a discrete choice model. The expected value of willingness to pay is then calculated from the estimated model. The chief advantage of the discrete choice model is that it considerably reduces strategic responses. It is claimed that this approach is incentive-compatible. There are two disadvantages. First, one must estimate a model and use the predicted value to determine willingness to pay. This introduces several arbitrary assumptions into the process. Second, relative to open-ended approaches, the dichotomous choice approach is not efficient. Researchers need many more observations to obtain the same level of precision as one would get if respondents answered open-ended questions without strategizing. Despite these shortcomings, however, the dichotomous choice model has become the norm for researchers. It has been recommended by the NOAA Blue Ribbon panel as the appropriate approach for administering contingent valuation questions for damage assessment.

they need to be told that their responses will actually be used in the decision making process. If the respondents treat the scenario as purely hypothetical, there is good chance that they may not take the survey question seriously. To minimize the bias arising out of such behavior, it is important that the scenario being presented to them be sufficiently credible. If the respondents do not believe into the scenario, there is a significant chance that the willingness to pay estimates obtained from CV responses will be biased.

Non-response Bias : Non-response bias occurs if there is a very low response to the CV questions and if the characteristics of the non-respondents are different from respondents. In that case, the willingness to pay is not likely to reflect the true willingness to pay. This type of bias is less likely to be significant in the case of personal interviews. In the case of telephonic or mail (electronic as well as traditional) surveys the non-response bias can be significant. One advantage of the discrete choice approach is that it tends to reduce non-responses. High non-response rates suggest an implausible or unrealistic scenario. A conservative approach that insures that the sample is representative is to treat the non-responses as no's.

Starting Point Bias: The starting-point bias can occur when respondents are asked whether they would be willing to pay a specific amount for the good or service in question. The bias occurs if the distribution of willingness to pay bids is affected by the opening bid. The notion is that the initial bid proposed reveals something to the respondent about what his or her willingness to pay should be. Starting point bias is especially prevalent with payment cards or bidding games.

Strategic bias: An important inquiry regarding the CV studies has been to ascertain whether CV responses are strategic. It has been argued that CV estimates are likely to suffer from strategic bias because no monetary transaction actually takes place at the time of the survey. Such a bias occurs if the respondents believe that their responses will influence the supply of the good but do not believe that they would actually be required to pay. Recently, some authors have even argued that willingness to pay estimates obtained from the CV studies should be adjusted downward (Diamond and Hausman, 1994).

The direction of bias resulting from strategic behavior usually depends on the payment mechanism described in the survey and the method used to elicit the response. In case of open-ended questions, for example, the respondents should answer extremely large amounts if they desire the good but do not believe that they would actually be required to pay. Similarly, they should give very low or zero as the willingness to pay amount if they believe that money will actually change hands. Based on a comprehensive review of a large number of studies, Mitchell and Carson (1989) found that the percent of respondents giving very large amounts is small, while the percent of respondents giving a zero willingness to pay is large. This suggests that CV estimates may actually underestimate the true willingness to pay. In fact, Carson *et al.* find that CV estimates on average tend to be lower than behavioral estimates for the same service.

The possibility of strategic behavior has resulted in growing use of dichotomous discrete choice CV questions in a referendum framework. If the respondents believe that their responses will actually influence the decision-making and that the likelihood of the good being provided will increase with the proportion of people responding yes, then the discrete choice questions can be shown to be incentive compatible. That is, the respondent can do no

better than saying 'yes' or 'no'. Other techniques such as open ended questions and bidding games provide the respondents much more opportunities for strategic behavior. Most of these techniques appear to introduce downward bias in the willingness to pay estimates if the payment mechanism is not credible. For this reason, this study used the dichotomous choice closed ended questions to elicit the willingness to pay. In the next section, we describe the scenario and the questions posed to the respondents for this study.

The CV instrument for eliciting willingness to pay for veterinary services in India

The effective practice of contingent valuation requires that most of the research effort be devoted to questionnaire design. This means care with the initial drafts, experimentation, with individual respondent, and pilot studies. This study attempted to follow what have come to be known as the best practices of CV design. Prescribed by the NOAA (National Oceanic and Atmospheric Administration) panel, these practices are designed to minimize some of the commonly known problems with CV technique. Table 1 summarizes these guidelines and the procedures followed in this survey to meet these guidelines. The scenario, question format, the follow-up questions etc. used in this survey are given below

Scenario A (for those who utilize the services at the centre): The government is starting a new scheme to provide services at the government veterinary centres. The plan of the scheme is as follows: The farmers will be given a yellow card. Only those who have the yellow card will be able to take their animals to the government veterinary centres and they will be provided services just like they are provided services currently. Of course, if you do not have the yellow card, you will still be able to call the veterinarian to your home and pay the price you pay now for home service. The cost of the yellow card is Rs. _____ and it will be good for one year.

Scenario B (for those who frequently call the veterinarian at home): The government is starting a new scheme for home service of government veterinarians. The plan of the scheme is as follows: The farmers will be given a blue card. Only those who have the blue card will be able to call the veterinarian to their home/field. If you do not have the blue

card, you will still have other options for treatment of sick animals. You will be able to take your sick animals to the government veterinary centre and pay the government set prices there. Or you may be able to hire the government vet for in-home services at much higher, perhaps double, prices that you pay now and with the chance that no service will available. The cost of the blue card is Rs. _____ and it will be good for one year.

Table 1: Contingent Valuation - NOAA guidelines and the procedures followed in this survey

Guideline	*Procedure followed*
1. Personal interview	All households personally interviewed
2. Referendum format. That is, the respondent should be made to vote to a given price rather than open ended questioning	Referendum format used.
3. The survey must begin with a scenario that describes the expected effects of the program under consideration	All households were described the scenario in the same manner including the expected effects
4. Survey should elicit willingness to pay for future incident rather than the past.	The scenario describes a future policy change.
5. Survey should remind the respondent that the payment would reduce consumption of other goods and services	Investigators were trained for that although a specific line in the survey did not appear
6. Remind about the availability of substitutes	Questions about alternative sources of information preceded the CV module
7. Follow-up questions to ensure that respondents understood the question being asked	Two sets of follow-up questions. One to ensure the respondents understood the scenario and the other to understand why they answered 'No' or 'Can't decide'

Source: Portney (1994) and Griffin et al (1995).

After describing the scenario, the farmers were asked a set of questions given below

1) Have you understood the scheme? Do you have any questions regarding the scheme?
Understands ___ Does not understand _____

(Those who said they did not understand were repeated the scenario)

2) Will you buy the yellow/blue card? Yes____ No____ Can't decide _____
If the answer is 'No', or 'Can't decide', then ask

3) Please tell us why you said `No' or `can't decide'

a) I still don't understand the scheme ___
b) I do not have enough money _____
c) I think the card is too costly _____
d) I do not believe the card will be needed for obtaining the service _____
e) Any other reason _____

If the answer to question 3 is b) or c) then ask,

If the yellow/blue card was available to you for Rs. _____ would you buy it? :

Yes _____ No_____Can't decide_____

The scenarios A and B set the general context of the problem. The payment mechanism is through the purchase of a card that would entitle them to the service. Such an instrument is relatively easy to enforce. It is also easy to exclude those who do not buy the card from obtaining the service. That lends some credibility that the service will actually be delivered.

The follow-up questions attempt to provide more insights into the farmers' responses. If the answer is a yes, no further questions are asked. If the answer is 'no' or 'can't decide' then the farmer is given a set of questions to ascertain the reasons for that response

1. *I still do not understand the scheme*: Even after repetition, the farmers has not understood the scheme. *A large proportion of such responses are a matter of concern and point to inadequate training of the investigators.*

2. *I do not have enough money:* Although the farmer agrees that the price at which the service is being offered to him is reasonable, the farmer is constrained by the availability of funds.

3. *I think the card is too costly*: Although the farmer believes in the usefulness of the service and is willing to pay, his willingness to pay is less than at which the card is being offered.

4. *I do not believe the card will be needed for obtaining the service:* The farmer is questioning the credibility of the scenario being presented to him. If a large number of respondents express the doubt about the experiment which could be due to the lack of faith in the ability of the provider to deliver the service or to exclude those who do not pay, or lack of credibility about the payment vehicle. *A large number of such responses suggest that there is a need to seriously rethink the design of the CV experiment.*

The set of follow-up questions provides fairly good assessment about what sort of biases may be entering the estimates. If, for example, a large proportion of respondents question the credibility of the scheme, it suggests that the estimates obtained will be influenced by the hypothetical bias or the payment vehicle bias. If, on the other hand, a large proportion of farmers do not fully understand the scheme but provide a response anyway, that suggests that the resulting estimates would be influenced by the information bias.

There is no sure way of minimizing these biases at the design stage. Thus, pre-testing of the experiment is a must. The pre-testing provides very useful clues to where the design may need modification. For the purpose of this study, the experiment was pre-tested twice in three very different villages and the results of the pre-test incorporated into the design. Even after the pre-test, the experiment was continuously monitored to ensure consistency.

Following the question 3 and the following up questions, the respondent is asked another referendum:

If the yellow/blue card was available to you for Rs. _____ would you buy it?

The purpose of this question is to provide more responses and greater efficiency in the discrete choice statistical analysis. From the structure of the questions, it can be seen that this question only follows up the 'no' responses. Empirical evidence suggests that attempts to obtain greater efficiency by asking follow-up questions for 'yes' responses tends to induce strategic behavior.

For this study we used five primary bid prices. That is, Rs. 300, 600, 900, 1200, and 1500 for the blue card and Rs. 100, 200, 300, 400, and 500, for the yellow card. For those who answered a no to the primary bid price were offered the second price which was one step lower than the primary bid. These bid prices were arrived at after extensive testing in the three villages.

The ultimate objective of the CV analysis is to obtain reasonable estimates of the willingness to pay for good or service in question. Both parametric and non-parametric methods can be used for that. The methodology for obtaining the point estimates as well as the behavioral basis of these models is explained below

Non-parametric estimation of the willingness to pay from dichotomous CV responses[2]

Although typical dichotomous response CV surveys offer a range of prices to the respondents, we begin this exposition with the case when a sample of N individuals is administered a dichotomous choice survey and every one is offered the same price. Case of multiple prices is taken up later.

Consider the case where each individual in a sample of n respondents is offered the card at the price of Rs. x. Denoting the willingness to pay of i^{th} individual by WTP_I one can safely conclude that $WPT_I \geq$ Rs.x if the respondent answers a 'Yes'. A no response on the other hand, implies that $WTP_i <$ Rs.x. Assuming the WTP is distributed randomly across the sample and denoting the cumulative distribution of WTP as F(W), one can write

(1) $P(WTP_i < x) = F_i(x)$

[2] This and the next section draw heavily from Haab and McConnell (forthcoming).

Where F(x) is the probability that the individual will be willing to pay an amount less than Rs.x. Since all individuals are offered the same price, a lower bound estimate of the expected willingness to pay is given by x*[1-F(x)]. That is, everyone who responds yes is assigned a willingness to pay equal to x, and everyone who responds no a willingness to pay of zero. However, since F(X) is not known, it needs to be estimated using the sample data. Denoting V_i =1 if the respondent answers a yes and 0 if the answer is no, the probability of V_i is given by

(2) $$P[V_i \mid F(x)] = F(x)^{(1-V_i)}\{1-F(x)\}^{V_i}$$

And the joint probability of observing the sample is given by

(3) $$P[V_i \mid F(x)] = F(x)^{\sum_i (1-V_i)}\{1-F(x)\}^{\sum V_i}$$

One way to estimate F(x) is to treat F(x) as an unknown parameter. Haab and McConnell (forthcoming) show that the maximum likelihood estimator of F(x) is given by the proportion of no responses to the offered price. That is,

(4) $$\hat{F} = \frac{n}{N}$$

Where n is the number of respondents answering no to the offered price and N is the sample size. Recall that the lower bound on expected willingness to pay is given by x*[1-F(x)]. That is

(5) $E(WTP) \geq x^*[1-F(x)]$.

Using the estimate of F into the expression for expected willingness to pay, we get

(6) $E(WTP) = x^*[1-n/N]$

And the variance of the lower bound of expected willingness to pay is given by

(7) $$V = x^2 \frac{\hat{F}(1-\hat{F})}{N}$$

Thus, if in a sample of 100 respondents 60 percent agreed to buy the yellow card at the price of Rs. 100, the lower bound on the expected willingness to pay would equal 100*.6 = Rs.60, and the variance of the distribution of lower bound on willingness to pay will be given by 100*100*.4*.6/100 = 2.4.

This illustrates the procedure for obtaining the lower bound on the willingness to pay when all respondents are offered the same bid price. Most dichotomous choice contingent valuation studies, however, use a distribution of bid prices. We now consider the case when respondents are offered multiple prices.

Suppose the respondents are offered m different prices. Then it is important to estimate the probability of a no response at every single price offered in the survey. For the multiple price case, Haab and McConnell (forthcomimg) describe the following procedure for obtaining the lower bound on the willingness to pay

1. For $j = 1....m$, calculate $F_j = [N_j / (N_j + V_j)]$
2. Beginning with $j = 1$, compare F_j and F_{j+1}.
3. If $F_{j+1} > F_j$, then continue.
4. If $F_{j+1} \leq F_j$ then pool cells j and j+1 into 1 cell with boundaries (x_j, x_{j+2}) and calculate

$$\hat{F}_j^* = \frac{n_j + n_{j+1}}{N_j + N_{j+1}}$$

5. Continue until cells are pooled sufficiently to allow for a monotonically increasing distribution function.

6. Calculate the probabilities as $\hat{f}_j^* = \hat{F}_j^* - \hat{F}_{j-1}^*$ and calculate the lower bound willingness to pay as $\sum_{j=0}^{m} x_j f_j^*$.

The next step is to obtain point estimate for mean and median willingness to pay. One way of doing that is to interpolate the distribution function between offered prices. The simplest way is the linear interpolation. That is, assume that the function (1 – F) is piecewise linear

between prices. In that case, the area under the function 1-F (which represents the probability of a yes response to each price) between the price x_j and x_{j+1} is given by

$$\int_{x_j}^{x_{j+1}} (1-\hat{F}(W))dW = (x_{j+1}-x_j)\frac{(2-\hat{F}_j^* + \hat{F}_{j+1}^*)}{2}$$

and summing over all offered prices gives the expected willingness to pay as

$$E(WTP) = \sum_j \ (x_{j+1}-x_j)\frac{(2-\hat{F}_j^* + \hat{F}_{j+1}^*)}{2}$$

The problem with implementing this formula, however, is that the function 1-F is not known at zero and the upper bound price. Part of this problem can be solved by assuming that the 1-F function to be non-negative. That is, the function goes to one at zero price. Similarly, one can define the function to go to zero at the upper bound of the willingness to pay. But, in most practical cases the upper bound is not known. What does one do in a situation like that? One way is to simply assume a reasonable upper bound and obtain the point estimate of the willingness to pay. One can even do some sensitivity analysis with respect to the assumed upper bound and assess if the point estimate is sensitive to the assumed upper bound.

Parametric estimation of the sample willingness to pay

We now turn our attention to parametric models of analyzing responses to dichotomous choice CV questions. These models not only allow the researcher to investigate the effect of a variety of independent variables on the willingness to pay, but also provide point estimates of mean and median willingness to pay without imposing arbitrary assumptions about upper bounds of willingness to pay. The downside of these models, however, lies in the risk of mis-specification. If the estimated and the true model are

significantly different, the magnitude and direction of the partial effects of the socio-economic variables can be misleading. However, with distributions that have similar ranges, the means estimated from different models will typically be similar.

Towards an estimable model

The random utility model of McFadden (1974) is the basic model for analyzing dichotomous CV responses within the parametric framework. Since such a survey confronts the respondent with only two choices -- "status quo" and "change from the status quo", the indirect utility function for the i^{th} respondent can be written as

(1) $$u_{im} = u_i(y_i, z_i, \varepsilon_{im})$$

where m= 0, 1, identifies whether or not the proposed change is implemented. Thus, u_{i0} is the total utility in the status quo and u_{i1} is the utility with the change. y_i is the i^{th} respondent's income, z_i is a vector of respondent characteristics and other demographic variables and ε_{im} is a random component. Given this utility function, the i^{th} respondent answers 'yes' to the offered price of x_i if the utility with the proposed change is greater than the utility of the status quo. That is, if

(2) $$u_{i1}(y_i - x_i, z_i, \varepsilon_{i1}) > u_{i0}(y_i, z_i, \varepsilon_{i0}).$$

Since, however, ε_{im} is observable to the respondent but not to the researchers, one can make only the probablistic statements about the response. The probability of a yes response for i^{th} respondent is the probability that $u_{i1} > u_{i0}$

(3) Prob (i^{th} respondent answers yes) = $\Pr ob(u_{i1}(y_i - x_i, z_i, \varepsilon_{i1}) > u_{i0}(y_i, z_i, \varepsilon_{i0}))$.

Assuming that the utility function is additively separable in deterministic and random components, we can write

(4) $u_m(y_i, z_i, \varepsilon_{im}) = v_m(y_i, z_i) + \varepsilon_{im}$

With this specification, the willingness to pay for the CV scenario relative to the status quo is written as

(5) $v_1(y_i - WTP(y_i, z_i, \varepsilon_{i1}), z_i) + \varepsilon_{i1} = v_0(y_i, z_i) + \varepsilon_{i0}$

Equation (5) defines the willingness to pay as a function of income and other plausible variables and the unobserved random component of the preferences as follows

(6) $\text{WTP} = y - v_1^{-1}(v_0 - \varepsilon)$ where $\varepsilon \equiv \varepsilon_1 - \varepsilon_0$

This represents the willingness to pay function expressed a function of income, consumption of other goods and a random component.

If we further assume that the deterministic part of the utility function is linear in income and other variables, we can write

(7) $v_{im}(y_i) = \alpha_m z_i + \beta_i(y_i)$

where α_m and β are parameters. With this specification of the utility function, the deterministic utility for the proposed CV scenario is

(8) $v_{i1}(y_i - x) = \alpha_1 z_i + \beta_1(y_i - x_i)$

and the status quo utility is

(9) $v_{i0}(y_i) = \alpha_0 z_i + \beta_0 y_i$

The change in deterministic utility is

(10) $v_{i1} - v_{i0} = (\alpha_1 - \alpha_0) z_i + \beta_1(y_i - x_i) - \beta_0 y_i$.

Assuming constant marginal utility of income between the two CV states, ( ) can be rewritten as

(11) $v_{i1} - v_{i0} = \alpha z_i - \beta x_i$

where $\alpha = \alpha_1 - \alpha_0$. The probability of responding yes now becomes

(12) Prob (i^{th} respondent responds yes) = Prob $(\alpha z_i - \beta x_i + \varepsilon_i > 0)$ = Prob $(\varepsilon_i < \alpha z_i - \beta x_i)$

where $\varepsilon_i \equiv \varepsilon_{i1} - \varepsilon_{i0}$.

The first step towards specifying an estimable model is to make certain assumptions about the random term. The standard assumption is that ε_i are independently and identically distributed with zero mean and finite variance. In addition, two widely followed distributions are normal and logistic. Assuming that $\varepsilon \sim N(0,\sigma^2)$., it can be shown that

(13) $\text{Prob}(\varepsilon < \alpha z_i - \beta x_i) = \text{Pr}ob(\theta < \frac{\alpha z_i}{\sigma} - \frac{\beta}{\sigma} x_i) = \Phi(\frac{\alpha z_i}{\sigma} - \frac{\beta}{\sigma} x_i)$

where $\theta = \frac{\varepsilon}{\sigma} \sim N(0,1)$ and Φ is the standard normal distribution function. This is the standard probit model. When ε is distributed logistic, then the cumulative distribution function is $\frac{1}{1+e^{-x}}$. That is, probability that i^{th} respondent answers yes is

(14) Prob(i^{th} respondent answers yes) = $\frac{1}{1+e^{-\frac{\alpha z_i - \beta}{\sigma_L}}}$

where σ_L is the normalizing variance. This is the logit model.

Thus, standard logit and probit models can be used to analyze the binary choice CV responses. Once we have estimated the model and obtained the point estimates of α and β, we can recover the willingness to pay from the following equality

(15) $\alpha_1 z_i + \beta(y_i - WTP_i) + \varepsilon_1 = \alpha_0 z_i + \beta(y_i) + \varepsilon_0$.

Solving for WTP_i and taking its expectation

(16) $E(WTP)_i = \alpha z_i / \beta$ -- expected willingness to pay

The median willingness to pay is given by the WTP that solves the expression that the probability that $u_1 = u_0$ is .5 . That is, the WTP which solves the following expression

(17) $\text{Prob}[\alpha_1 z_i + \beta(y_i - WTP_i) + \varepsilon_1 = \alpha_0 z_i + \beta y_i + \varepsilon_i] = .5$

$= \text{Prob}\, WTP = [\alpha z_i / \beta + \varepsilon / \beta] = .5$

Since ε is symmetric with mean zero, this expression yields

(18) Median willingness to pay, $WTP_i = \dfrac{\alpha z_i}{\beta}$

Thus, for the linear utility function, the expected mean and the median turn out to be equal.

There are some disadvantages to the strictly linear model. The income term drops out, leaving a model in which income has no influence on choice. Further, departure from linear income models can sometimes provide models that appropriately bound willingness to pay. In the linear model, the distribution of willingness to pay can have a partly negative range with reasonable parameter estimates. Further, some parameter estimates can lead to a negative mean willingness to pay. A non-linear income model is a reasonable point of departure for these two problems.

To illustrate the case of non-linear utility function, we consider the utility function of the form

$$v_m(y_i, z_i) + \varepsilon_{im} = \alpha_m + \beta \ln(y_{im}) + \gamma_i z_i + \varepsilon_{i0}$$

This utility function is log-linear in income and relaxes the assumption of constant marginal utility of income. Substituting, this utility function into the random utility probability statement and rearranging again leads to standard logit and probit models

$$Prob\left[-\alpha-\beta\ln\left(\frac{y_i-x_i}{y_i}\right)-\gamma z_i>\varepsilon_i\right]$$. where $\alpha=\alpha_1-\alpha_0$, $\gamma=\gamma_1-\gamma_0$ and $\varepsilon_i=\varepsilon_{i1}-\varepsilon_{i0}$

Assuming ε_i is distributed normally with mean zero and variance σ^2 results in the standard normal probability of a yes response as follows

$$\text{Prob}(i^{th}\text{ respondent answers yes})=\Phi\left(\frac{-\alpha-\beta\ln\left(\frac{y_i-x_i}{y_i}\right)-\gamma z_i}{\sigma}\right)$$

and the estimation of the parameters can be accomplished by running a simple probit model. The assumption of logistic distribution, on the other hand, results into standard logit model. The expected mean and the median willingness to pay for log-linear utility function are obtained as follows

Measure/Model	Probit Model	Logit Model
Expected mean willingness to pay	$y_i-y_i e^{-\frac{\alpha}{\beta}-\frac{z}{\beta}z_i+\frac{1}{2}\frac{\sigma^2}{\beta^2}}$	$y_i-y_i\frac{(\alpha/\beta)\pi}{Sin(\alpha/\beta)\pi)}e^{-\frac{\alpha}{\beta}-\frac{z}{\beta}z_i}$
Median willingness to pay	$y_i-y_i e^{-\frac{\alpha}{\beta}-\frac{z}{\beta}z_i}$	$y_i-y_i e^{-\frac{\alpha}{\beta}-\frac{z}{\beta}z_i}$

While the non-linear model may dispose of the negative range of willingness to pay, the errors of measurement in income may lead to considerable imprecision in parameter estimates because of errors in measurement of income. An alternative is simply to specify a non-negative willingness to pay function. For example, a willingness to pay function of the form (where y is income and z is a vector of other characteristics viewed as important in determining willingness to pay):

$$WTP(y,z) = \exp(\alpha y+\beta z+\varepsilon)$$

leads to a log-probit or log-logit estimation when ε is distributed normally or logsitically. It can be estimated with the application of a logit or probit model. It leads to an estimate of median willingness to pay equal to .

Median (WTP) = $\exp(\alpha y+\beta z)$, where the parameters are estimated via maximum likelihood.

Conclusion

The ultimate goal of the contingent valuation is to determine what representative farmers are willing to pay for animal health and breeding services. Credible measures require careful survey design, quality control of the interview and data recording process, and cautious use of econometric models for inferring values. Some additional uses may require expansion of sample estimates to the population of poor farmers. There are basically two ways to expand. If the sample can be considered representative of the population, then means can be expanded to totals by simple extrapolation. However, if the sample is not representative, then the appropriate weighting factors must be incorporated in the sample expansion. In either case, the sample is likely to be expanded from a small sample to a very large population, and the potential that small sample errors are compounded into very large errors at the population level must be carefully monitored.

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