I. Introduction and General Description of the Method of Contingent Valuation

Contingent Valuation is a method of estimating the value that a person places on a good. The approach asks people to directly report their willingness to pay (WTP) to obtain a specified good, or willingness to accept (WTA) to give up a good, rather than inferring them from observed behaviours in regular market places.

Because it creates a hypothetical marketplace in which no actual transactions are made, contingent valuation has been successfully used for commodities that are not exchanged in regular markets, or when it is difficult to observe market transactions under the desired conditions.

Although it is certainly possible to employ contingent valuation for commodities available for sale in regular marketplaces, many applications of the method deal with public goods such as improvements in water or air quality, amenities such as national parks, and private non-market commodities such as reductions in the risk of death, days of illness avoided or days spent hunting or fishing.

Contingent valuation has proven particularly useful when implemented alone or jointly with other valuation technique for non-market goods, such as the travel cost method or hedonic approaches. It remains the only technique capable of placing a value on commodities that have a large non-use[1] component of value, and when the environmental improvements to be valued are outside of the range of available data.

Much controversy surrounds the use of CV when most of the value of the good derives from passive use, as has been typical in litigation over the damages to natural resources and amenities caused by releases of pollutants. Critics of contingent valuation allege that the quality of stated preference data is inferior to observing revealed preferences, consider contingent valuation a "deeply flawed method" for valuing non-use goods and point at the possible biases affecting contingent valuation data.

Despite these criticisms, CV has formed the basis for a significant amount of policymaking in the United States (see Cropper and Alberini, 1998, for examples). Recently, the World Bank, the United States Agency for International Development and other donor agencies have taken an interest in contingent valuation as a means of assessing the demand for sanitation services, improvements in the water supply, the benefits of establishing national parks and the costs/benefits of restricting land use to reduce tropical deforestation in developing countries. Because the proposed improvements in sanitation and/or water supply currently do not exist at the location of the study, willingness to pay for improved services cannot be extrapolated from the existing conditions or from the expenditures incurred to secure the current level of sanitation or water supply, making it necessary to use "stated preference" approaches (such as contingent valuation) which ask individuals what they would do under hypothetical circumstances.

Based on the results of contingent valuation studies, researchers have been able to predict the number of connections to water supply systems at improved conditions, and the resulting revenue for the local water authority, making it possible to study the feasibility of such improvements and of various financing schemes. Recent work by the World Bank shows that contingent valuation correctly predicted 91 percent of the actual connections to the piped water system (Cropper and Alberini, 1998).

---

[1] Non-use values relate to the utility that a person experiences from knowing that a natural resource or amenity exists and may be experienced by other people or future generations, even though he/she has never visited it nor plans to.

Our view of the contingent valuation studies conducted in developing countries, which we discuss in this report (section II) and summarize in the tables in the Appendix, is that most of them have been designed and implemented following rigorous standards in the economics profession.

To elaborate on this point, it appears that the majority of these studies pose willingness-to-pay questions using dichotomous choice approaches, asking the respondents whether or not they would purchase the specified commodity at the stated prices. This approach is nowadays preferred over alternative approaches, because it reduces the cognitive burden placed on the respondent, and mimics the behaviour of people in regular marketplaces. When follow-up questions were used to obtain more precise information about the respondent's WTP amount, the analysts usually took care to examine whether mean WTP would change with each new round of information as a result of strategic behaviour on the part of respondent.

Researchers involved in applications of CV in developing countries also appear to have tested the survey materials carefully. For instance, undesirable reactions to the use of photographs led Shyamsundar and Kramer (1996) to drop visuals aids from their survey, while observing that respondents were reporting WTP out of a sense of coercion led to rephrase their valuation question in favour of eliciting WTA to forgo access to forest areas.

In general, internal validity analyses have found that WTP relates well to the household's economic circumstances and the household's cost of obtaining substitutes for the commodity described in the survey. For instance, WTP for improved water service is usually higher when the household faces high cost of securing alternative water supplies, and women, who in developing countries are often responsible for obtaining water for their household, have sometimes (but not always, probably for cultural reasons) reported higher WTP for in-house or public tap connections.

However, CV practitioners conducting studies in developing countries have had to struggle with a variety of problems. To illustrate, in the absence of lists of dwellings and households at the location of interest, samples have sometimes been drawn using ad hoc assumptions. Coverage of a small geographic area has sometimes resulted in the target community's awareness that a study was being conducted, and in subsequent attempts by community leaders to use their influence to manipulate survey responses in hopes of influencing the provision of the commodity.

Respondents have struggled with the notion of maximum willingness to pay, or have been found to report very low WTP for a commodity (e.g. the public water supply system) when their actual expenditures for purchasing water from alternative sources, such as private vendors, are much higher. This has been attributed to seasonal cash constraints related to the agricultural labour market, and to the fact that under such constraints households are unwilling to commit to regular payments to the water authority.

At many locations in Asia and Africa, respondents distrust the government, which they blame for the current state of disrepair of equipment and facilities, and this is reflected in their low WTP for commodities or services such as regional-level sanitation, water quality programmes and local water supply. It has also been difficult in some cases to describe the technology that would bring the specified sanitation improvement, and researchers have been forced to craft the CV questionnaire in imaginative ways to get around this problem.

Despite these difficulties, we are confident that proper application of contingent valuation can and will provide valuable information to policy-makers and donor agencies seeking to evaluate the benefits of intervention, or the revenues associated with investment in infrastructure.

In the remainder of section I of this report, we present a brief description of the contingent valuation method. We provide formal definitions for the welfare measures (WTP or WTA) elicited through a contingent valuation survey (section I.A), describe the most popular survey formats and elicitation approaches (sections I.B, I.C and I.D), discuss potential problems in implementing the method, and explain the statistical analysis of the data used to obtain estimates of mean or median WTP (or WTA; sections I.E, I.F and I.G).

Section II specifically discusses CV applications in developing countries, summarizing the sampling techniques used and related problems (section II.A), the most popular elicitation formats and related strategic considerations (sections II.B and II.C), problems arising with the respondents' distrust for the government (section II.D), how practitioners have described the commodity to be valued to the respondents (section II.H) and how CV has been found to compare with alternatives ways to place a value on a non-market commodity (section II.G).

Applications to specific commodities, such as the public waters supply system and health endpoints, are covered in sections II.E and II.I. Additional methodological issues and extensions are discussed in sections II.J and II.K. The developing country studies covered in this report are summarized in tabular form in the Appendix.

A. WTP and WTA

The goal of contingent valuation is to measure the compensating or equivalent variation for the good in question. Compensating variation is the appropriate measure when the person must purchase the good, such as an improvement in environmental quality. Equivalent variation is appropriate if the person faces a potential loss of the good, as he would if a proposed policy results in the deterioration of environmental quality. Both compensating and equivalent variation can be elicited by asking a person to report a willingness to pay amount. For instance, the person may be asked to report his WTP to obtain the good, or to avoid the loss of the good. Formally, WTP is defined as the amount that must be taken away from the person's income while keeping his utility constant:

$$(1) \qquad V(y - WTP, p, q_1; Z) = V(y, p, q_0; Z)$$

where V denotes the indirect utility function, y is income, p is a vector of prices faced by the individual, and q_0 and q_1 are the alternative levels of the good or quality indexes (with $q_1 > q_0$, indicating that q_1 refers to improved environmental quality).

Willingness to accept for a good is defined as the amount of money that must be given to an individual experiencing a deterioration in environmental quality to keep his utility constant:

$$(2) \qquad V(y + WTA, p, q_0; Z) = V(y, p, q_1; Z) \cdot$$

In equations (1) and (2), utility is allowed to depend on a vector of individual characteristics influencing the trade-off that the individual is prepared to make between income and environmental quality. An important consequence of equations (1) and (2) is that WTP or WTA should, therefore, depend on (i) the initial and final level of the good in question (q_0 and q_1); (ii) respondent income; (iii) all prices faced by the respondent, including those of substitute goods or activities; and (iv) other respondent characteristics. Internal validity of the WTP responses can be checked by regressing WTP on variables (i)-(iv), and showing that WTP correlates in predictable ways with socio-economic variables.

In theory, absent income effects and when WTP is a small fraction of income, WTP and WTA for a given commodity should be approximately equal. However, a number of CV studies have found that WTA is often much larger than WTP for the same commodity. Various explanations are possible for this finding. One explanation is that the difference between WTP and WTA depends on the elasticity of substitution between the commodity to be valued (a public good) and private substitutes. The lower such elasticity, and the fewer the available substitutes, the greater the difference between WTP and WTA (Hanemann, 1991). Another explanation – the theory of prospects – is that individuals value losses more heavily than gains. It is also possible that individuals react to their perception of who has the property rights over the commodity in question. If the proposed policy contradicts their perception of the existing property rights, individuals might express their rejection of the scenario through high WTA values. This might happen if, for example, individuals believe that they are entitled to clean air, and are outraged at a proposed degradation in air quality. In practice, some or all of these alternative explanations may coexist. Carson (1991) suggests that WTP should be used whenever the individual might incur benefits from the proposed policy, and Mitchell and Carson (1989) offer ways to frame the payment question to elicit WTP. However, even when the individual might incur benefits from the proposed policy, there are some scenarios under which the respondent may not overstate WTA values (Cooper and Osborn, 1998).

B. Survey Methods

As earlier explained, the contingent valuation method (CVM) relies on directly querying individuals about their WTP (WTA) for a specified improvement (degradation) in environmental quality in the course of an interview.

Various survey methods are possible. In-person interviews are generally held to produce the highest-quality WTP data, but are very expensive. Carson (personal communication) estimates that the cost of a completed interview in the well-known Alaska study (see Carson *et al*., 1994) was $300 to $400. Telephone surveys are much less expensive and can produce high-quality data, but do not lend themselves to lengthy descriptions of the scenario, or to the use of photographs and visual aids.

Mail surveys are even less expensive than telephone surveys, but completion of the questionnaire by the respondent is likely to be correlated with his WTP for the commodity being valued, implying a self-selected type of sample. However, Cameron, Shaw and Ragland (1996) show how to correct for sample-selection bias using Census information at the zipcode level for the addressees to whom the questionnaires were mailed.[2] Mail surveys also make it

---

[2] Specifically, denote with **x** a set of characteristics of the residents of the area corresponding to zipcode j (j=1, 2, …, J) thought to affect the questionnaire return rate, such as the percent of adults with a college degree, median household income, and median age. A probit model can be estimated to predict the likelihood that addressee i at zipcode j returns the questionnaire: Pr(questionnaire returned by i)=$\Phi(\mathbf{x}_{ij}\alpha)$, where $\Phi(\cdot)$ is the standard normal cumulative distribution function (cdf). Willingness to pay is then corrected for participation, based on the assumptions that propensity to participate in the survey and WTP are correlated, and that WTP follows the normal distribution, producing the following regression:

$$WTP_{kj} = \mathbf{z}_{kj}\beta + \delta \cdot \frac{\phi(\mathbf{x}_{kj}\hat{\alpha})}{1-\Phi(\mathbf{x}_{kj}\hat{\alpha})} + \text{error term},$$

where k$\in$ {set of respondents who returned the questionnaire}, j=1, 2, …, J, and $\Phi(\cdot)$ is the standard normal density.

difficult to ask questions that depend on the answer to previous questions, as is the case with follow-up questions about WTP. As we discuss in a later section, telephone and mail surveys may not be practical in some LDC situations, leaving in person surveys as the method of choice. Given that in-person surveys are labour intensive, one would expect these to be much cheaper to conduct in LDCs than in DCs.

Finally, some studies have been conducted using convenience samples drawn from University staff, college students, and by intercepting passers-by at shopping malls. Such samples may be acceptable when the purpose of the study is to test methodological aspects (such as the effect of the wording of the questionnaire, or the effect of presenting respondents with commodities defined in different ways), but do not allow the researcher to extrapolate values to the general population. In addition, when the subjects participating in the study are college students, insufficient variation in their individual characteristics usually prevents the researcher from investigating the relationship between these characteristics (such as age, income, family status) and WTP.

C. Structure of the Questionnaire

Most contingent valuation surveys open with general ("warm-up") questions aimed at making the respondent comfortable with participating in the survey and answering questions. This is usually followed with a description of the scenario depicting a plan for the provision of a public good, a change in environmental quality, or a change in the private commodity to be valued (such as a reduction in the risk of mortality associated with pollution exposures, or the recurrence of an episode of illness to be experienced by the respondent). This description may be aided with accompanying materials, such as charts, photographs etc.[3] In in-person and telephone surveys respondents are usually allowed to ask questions, and may be offered a summary of the positive and negative aspects of the good or policy at the end of the scenario description.

This is followed by the payment question, which queries respondents about their WTP for the proposed plan (or about their WTA to accept a degradation in environmental quality or the loss of access to a natural resource). It is important that respondent be explicitly told what the payment vehicle is, i.e., the method through which payments would be incurred by people to finance the provision of the good or the policy delivering the improvement in environmental quality. For instance, to improve air quality power plants might be required to install (additional) pollution control equipment. To pay for the associated capital costs, a surcharge may be added to the respondent's electricity bill over a specified number of billing periods. Would the respondent be willing to incur such surcharges to secure the emissions reductions, and if so, what is the maximum amount he would be willing to pay? Respondents have also been asked to name the maximum increase in income taxes that they would be prepared to incur to finance the government programme that would deliver the improvement in environmental quality, and the maximum increase in the cost of purchasing products manufactured by the firms which are to install pollution equipment control.

Questions about socio-demographics are usually placed in the last portion of the survey questionnaire. These typically include the respondent's age, household income, marital status,

---

[3] For instance, in the study by Carson *et al*. (1994) intended to estimate the loss of non-use values of the natural resources of Prince William Sound, Alaska, caused by an oil spill, respondents were shown photograph of the landscape and wildlife of Prince William Sound, and an illustration showing how oil spills may be contained by deploying "sea fences" and vacuuming.

number of dependents, educational attainment, and some general "attitude" questions, such as whether the respondent consider himself or herself an environmentalist.

D. WTP Elicitation Techniques

In early applications of the CVM, respondents were often asked open-ended questions about their WTP. An open-ended question might be worded as follows: "What is the most you would be willing to pay for …?" and is intended to elicit a point estimate of the respondent's WTP. Appealing as this approach might be, it is nowadays less and less frequently used, due to the obvious respondent difficulty in answering the payment question, which results in many missing values for WTP.

The iterative bidding approach (Randall *et al*., 1974) starts by querying individuals at some initial dollar value and keeps raising (or lowering) the value until the respondent declines (accepts) to pay. This final dollar amount is interpreted as the respondent's WTP. However, this approach has been virtually abandoned because it tends to result in starting point bias, an effect such that the final WTP amount at the end of the bidding game is systematically related to the initial bid value. Another disadvantage of the approach is that repeated questioning may annoy or tire respondents, causing them to say "yes" or "no" to a stated amount in hopes of terminating the interview.

An alternative approach is to list a number of possible WTP values on a card, and to ask the respondent to pick the amount on the card that best represents his willingness to pay. The amount chosen by the respondent can be interpreted as the respondent's WTP. A more precise interpretation, formalized in Cameron and Huppert (1988), is that the chosen amount is a lower bound for the respondent's WTP, the upper bound being the next highest amount on the card. Although under this interpretation WTP is not directly observed, statistical models can be fit that allow one to obtain the parameters of the distribution of WTP, and to make a prediction about a respondent's expected WTP amount.

The payment card approach has been criticized on the grounds that respondents might limit their announced WTP to the values listed on the card, but recent research by Rowe, Chestnut and Breffle (1996) shows that this needs not be a concern, provided that that the dollar values listed on the card are not truncated from above. The payment card approach remains a popular way of eliciting WTP.

The most widely used approach to eliciting information about the respondent's WTP is the so-called dichotomous-choice format. A dichotomous choice payment question asks the respondent if he would pay $X to obtain the good. A frequently used wording of the payment question is whether the respondent would vote in favour of the proposed plan or policy if approval of the plan would cost his household $X (in the form of extra taxes, higher prices of products, etc.). There are only two possible responses to a dichotomous choice payment question: "yes," and "no" (or "vote for" and "vote against"). The dollar amount $X is varied across respondents, and is usually termed the bid value.

The dichotomous choice approach mimics behaviour in regular markets (at least, in Western countries), where people usually purchase, or decline to purchase, a good at the posted prices. It also closely resembles people's experience with political markets and propositions on a ballot. The dichotomous choice approach has also been shown to be incentive-compatible: provided that respondents understand that provision of the good depends on the majority of votes, and the respondent's own vote in itself cannot influence such provision, truth-telling is in the respondent's best interest (Hoehn and Randall, 1987).

It is important to note that the dichotomous choice approach does not observe WTP directly: at best, we can infer that the respondent's WTP amount was greater than the bid value (if the respondent is in favour of the programme) or less than the bid amount (if the respondent votes against the plan), and form broad intervals around the respondent's WTP amount. Mean WTP is estimated by fitting special statistical models of the responses (see section I.F below).

To improve the precision of the WTP estimates, in recent years researchers have introduced follow-up questions to the dichotomous choice payment question (e.g., Hanemann, Loomis, and Kanninen, 1991). To illustrate, consider a respondent who states he is not willing to pay $10 for the proposed plan. The follow-up question might ask him if he would pay $5. If the respondent answers "no" to both questions, it is assumed that his WTP amount falls between 0 and $5. If the respondent answers "no" to the initial question, and "yes" to the follow-up questions, it is assumed that his WTP amount falls between $5 and $10. The bid level offered in the follow-up question will be greater than that offered in the initial payment question if the answer to the initial payment question is "yes."

It is also possible to introduce a second follow-up question (Alberini *et al*., 1997a), but evidence based on Monte Carlo simulations (Cooper and Hanemann, 1994; Cooper, Hanemann, and Signorello, 1999), suggests that most of the statistical efficiency gains in the estimation of mean WTP come from the first follow-up question. In choosing the bid level to be assigned to the respondent in the follow-up question, it is important that this follow-up bid be sufficiently different from the initial bid (so that it could be justified to the respondent as two different engineering estimates of the cost of the project), but not so different as to compromise the credibility of the survey. If the initial question was $25, it makes little sense to query the respondent about $26 or $2000. Depending on the design, a discrete choice format with follow-up(s) can mimic a bargaining process, a trait that can be useful in an LDC context.[4]

Some recent studies (see for instance Alberini *et al*., 1997b) examine WTP for government programmes, finding that mean WTP estimated after the follow-up questions can be lower than that implied by the responses to the initial payment question. A possible explanation for this finding is that some respondent may treat the suggested cost of the project as a signal for the quality of the programme and/or might erroneously believe that the programme to be valued in the follow-up is different from the initial one.[5] In other studies where the good to be valued was a private non-market good (days of illness) estimated WTP remains very stable over the rounds of follow-ups (Alberini *et al*., 1997a).

Finally, in some studies the dichotomous choice follow-up question is followed by an open-ended follow-up question ("what is the most you would pay for …?").

Following the prescriptions of the NOAA Panel on Contingent Valuation (Arrow *et al*., 1993) called to examine the validity of the CVM is estimating non-use values, many recent

---

[4] Of course, a format which presents a high follow-up to an "initial" yes response does not mimic a realistic bargaining process, while a process that stops after the respondent says "yes" or that gives a lower bid after the respondent says "no" to the first bid does.

[5] Respondents who answered "yes" to the initial payment question might think that the government is perfectly capable of providing the program at the cost initially stated, and that the additional money collected (as per the follow-up question) would be wasted by the government. Respondents who answered "no" to the initial payment question might think that the program provided to them at the (lower) cost stated in the follow-up question is a scaled-down, lower-quality variant of the government program. To the extent that this is true, respondents would tend to answer "no" to the follow-up question, thus lowering the final WTP estimate.

Figure 1: Multiple-bounded payment questions

Cost	Definitely Yes	Probably Yes	Not Sure	Probably No	Definitely No
$1	□	□	□	□	□
$5	□	□	□	□	□
$10	□	□	□	□	□
$20	□	□	□	□	□
$50	□	□	□	□	□
$100	□	□	□	□	□
$500	□	□	□	□	□
$1000	□	□	□	□	□

studies have offered additional response categories expressing uncertainty. Carson *et al*. (1998) show that explicitly allowing for a "not sure" or "would not vote" category ends up generating more such responses than are spontaneously volunteered by respondents offered only the yes/no options. However, the split between votes in favour and against *among those respondents who did vote* was similar.

Ready *et al*. (1995) use a variety of response categories and estimate ambivalence bounds, i.e. the range of dollar values within which the respondent does not know whether he prefers the status quo, or the provision of the programme at the stated cost. Wang (1997) designs a survey instrument which gives respondent the option to answer "yes," "no" or "don't know," and argues that WTP must be sufficiently high (low), relative to the bid amount, for the respondent to answer "yes" or "no" with confidence. The resulting statistical model is a variant of the ordered probit model. The thresholds that WTP must exceed (be well lower than) for the respondent to answer "yes" ("no") is allowed to depend on individual characteristics. Cooper and Osborn (1998) suggest that the percent who answer "don't know" should fall as the time frame between the payment question in the CV survey and when a payment decision has to actually be made decreases.

Welsh and Poe (1998) compare the polychotomous-choice, multiple-bounded elicitation approach with the more traditional elicitation approaches, finding that the former is capable of predicting the results from the latter, and yields considerably more efficient WTP estimates. In a polychotomous-choice, multiple-bounded CV survey, respondents are presented with a *panel* of bid values and a number of response categories arranged in a matrix, and are asked to check the degree of confidence with which they feel they would or would not pay *each* amount listed on the card, as shown in Figure 1.

In Figure 1 five possible response categories were used, but these could be expanded to include more options, collapsed into fewer options, or labelled using a numerical scale to denote the strength of the respondent's beliefs (Ekstrand and Loomis, 1998). Welsh and Poe (1998) argue that the respondent's WTP amount is bracketed by the highest bid level which the respondent was "definitely" or "probably" willing to pay, and the lowest bid level for which the respondent was "unsure" or downright unwilling to pay.

In practice, economic theory does not provide a rationale for the use of polychotomous-choice responses, and the researchers that have utilized this elicitation format have been forced to make arbitrary assumptions when specifying the econometric model for the responses (Alberini, Boyle and Welsh, 1999).

E. Handling the Data

Prior to fitting the desired statistical models of the WTP responses, it is advisable to perform basic checks of the data. WTP figures that are unrealistically large, given the income of the

respondents, may be data entry errors, or signal that the respondent has given little consideration to his or her budget constraint when announcing his or her value of the commodity. When the good to be valued is a public policy affecting environmental quality, Carson (personal communication) suggests inspecting the data to see if any respondents have reported WTP figures in excess of five percent of their household income. Analyses should be carried out that, in turn, include and exclude such respondents from the usable sample to see if these observations unduly influence the WTP estimates.

Another type of response that may be uncovered during the data cleaning stage of the analysis – but can be sometimes be avoided by carefully crafting the survey questionnaire – are so-called "protest zeros". A respondent who has a positive WTP amount for the commodity may provide a "protest zero" value when answering the payment question if he or she disagrees with some aspects of the scenario described in the survey. For instance, the potential for "protest zeros" was recognized to be high in the survey conducted for the office of the General Attorney of the state of Alaska by Carson *et al*. (1994). The survey elicited the public's WTP for a ship escort and emergency response plan that would reduce the likelihood of oil spills in Prince William Sound (the site of the Exxon Valdez oil spill of 1989) and promptly contain the release of oil in the event of an accident. Although people generally highly value a plan that reduce the damages to wildlife and coastal resources, some people may feel that it is the oil company's responsibility to ensure safe transportation of oil, and may refuse (or fail to) recognize that when oil companies are made to pay for the ship escort/emergency response plan, they will simply pass the cost of these measures onto the consumers in the form of higher prices. Carson *et al*. specifically told respondents that oil companies would pay as well to minimize the chance of a "protest zero".

It is often difficult to distinguish a "protest zero" from a respondent who genuinely has no value at all for the commodity. "Protest zeros" are usually recognized from the answers to questions *other* than the WTP questions. Debriefing questions towards the end of the questionnaire, or spontaneous comments offered by the respondent in the course of the interview (in telephone or in-person surveys), usually aid the researcher in identifying "protest zeros."

F. Statistical Analysis of the Responses

The purpose of the payment question is to obtain information about the respondent's WTP amount. WTP responses must be statistically analysed to obtain an estimate of mean WTP, which is multiplied by N, the size of the population affected by the proposed policy, to produce total WTP. Total WTP can then be compared with the cost of implementing the policy to determine whether the proposed policy passes a benefit-cost test.

If the payment question is open-ended, the WTP figures reported by the respondents can simply be averaged to produce an estimate of mean WTP:

$$(3) \qquad MWTP = \frac{1}{n}\sum_{i=1}^{n} y_i$$

where n is the sample size and each y is a reported WTP amount.

Average WTP may be deceivingly high if few individuals report very high WTP amounts. That averages can be "dominated" by few very large observations is a well-known problem in statistics, and the statistical literature has proposed a number of ways for identifying such observations and reduce their impact on the sample mean. For contingent valuation data, Carson (1991) proposes the use of an a-trimmed sample mean, where a is set at a predetermined

percentage. An a-trimmed average is essentially a weighted average that attaches a weight of zero to the largest and lowest a×100 percent of the observations, effectively disregarding them.

The sample average is the best (i.e. lowest-variance) estimator of the true population mean only if the distribution of WTP is a normal. However, it is reasonable to assume that in many CV studies the distribution of WTP is *not* a normal: A normal distribution allows negative values, which can be ruled out for many of the commodities under investigation in a CV survey.[6]

If the distribution of the population is not a normal, the sample average remains a valid way to estimate the true population mean, but the maximum likelihood estimate of mean WTP is more statistically efficient. Estimating the mean by the method of maximum likelihood requires that a distribution be specified for WTP. For instance, one may wish to assume that distribution of WTP is a Weibull with parameters θ and σ, and cdf $F(y) = 1 - e^{-(y/\sigma)\theta}$. The most efficient estimate of mean WTP in this case is obtained as

$$\hat{\sigma} \cdot \Gamma\left(\frac{1}{\hat{\theta}} + 1\right),$$

where $\hat{\sigma}$ and $\hat{\theta}$ denote the maximum likelihood estimates of the parameters, and G(·) is the gamma function.

Another problem with open-ended responses is that samples are typically "lumpy" (e.g., many individuals report the same WTP values, such as $15.00, $20.00, etc.) and affected by rounding errors, a problem that has been ignored in most CV studies using the open-ended approach.

Dichotomous choice payment questions typically require a different type of statistical analysis, based on the assumption that if the individual states he is willing to pay the bid amount, his WTP must be greater than the bid. If the individual declines to pay the stated amount, than his WTP must be less than the bid. In both cases, the respondent's actual WTP amount is not observed directly by the researcher. Let WTP* be unobserved willingness to pay, which is assumed to follow a distribution F(θ), where θ is a vector of parameters, and form an indicator, I, that takes on a value of one for "yes" responses and 0 for "no" responses. The probability of observing a "yes" (or I=1) when the respondent has been offered a bid equal to B_i is:

$$(4) \qquad \Pr(I_i = 1) = \Pr(WTP_i^* > B_i) = 1 - F(B_i;\theta)$$

whereas the probability of observing a "no" (or I=0) is simply $F(B_i;\theta)$, i.e. the cdf of WTP evaluated at the bid value. The log likelihood function of the sample is:

$$(5) \qquad \sum_{ii=1}^{n} \left[I_i \cdot \log(1 - F(B_i;\theta)) + (1 - I_i) \cdot \log F(B_i;\theta) \right].$$

If WTP is normally distributed, F(·) is the standard normal cumulative distribution function, and $F(B_i;\theta) = \Phi(B_i;\sigma\text{-}\mu/\sigma)$, where the symbol Φ denotes the standard normal cdf, μ is mean

---

[6] Consider for instance the study by Alberini *et al*. (1997a), in which respondents were queried about their WTP to avoid an episode of illness: A negative WTP would have implied that individuals are actually willing to pay to be sick!

WTP and σ is the standard deviation of the distribution. If WTP follows the log normal distribution (and is hence defined only for non-negative values), $F(B_i;\theta) = \Phi(\log B_i; \sigma\text{-}\mu/\sigma)$, where μ and σ are the mean and standard deviation of the logarithmic transformation of WTP, and mean WTP is equal to $\exp(\mu + 0.5\cdot\sigma^2)$. Other distributions are possible: In much applied work, WTP is assumed to be a logistic with cdf equal to $1/(1+\exp(-z))$, where z $= \mu/\sigma - B/\sigma$. After equation (5) is specialized to the desired WTP distribution, the parameters can be estimated directly by maximizing (5).

If WTP follows the normal or logistic distribution, the coefficients can be estimated using the probit estimation routine available in many statistical packages such as LIMDEP, SAS, GAUSS, STATA, etc.[7] Specifically, one runs a probit regression of the dependent variable I (the yes/no indicator), on a constant and on an independent variable consisting of the bid level. The intercept, α, of the probit model obtained in this fashion is equal to μ / σ, whereas the slope coefficient, β, is equal to -1/s.

One recovers estimates of the original μ by dividing $\hat{\alpha}$ by $(-\hat{\beta})$, and of the original σ as $\hat{\sigma} = -1/\hat{\beta}$.

The probit routine will automatically produce standard errors for $\hat{\alpha}$ and $\hat{\beta}$, but not for $\hat{\mu}$ and $\hat{\sigma}$.[8] To obtain the variances of the latter estimates, researchers have resorted to a variety of techniques. The most straightforward is that based on the "delta method," illustrated for dichotomous choice contingent valuation data by Cameron (1991). To obtain the covariance matrix of $\hat{\mu}$ and $\hat{\sigma}$, one first needs the covariance matrix of $\hat{\alpha}$ and $\hat{\beta}$ produced by the probit routine, here denoted as **V**. The expression for **V** is:

$$(6) \qquad \mathbf{V} = \left\{ \sum_{i=1}^{n} w(z_i) \begin{bmatrix} 1 & B_i \\ B_i & B_i^2 \end{bmatrix} \right\}^{-1},$$

where $z_i = \hat{\alpha} + \hat{\beta}\cdot B_i$, and $w(z_i) = \phi^2(z_i)/\{\Phi(z_i)[1-\Phi(z_i)]\}$, with ϕ(•) the standard normal probability density function (pdf). Next, it is necessary to compute the matrix **G**, with

$\mathbf{G}=\begin{bmatrix} -1/\hat{\beta} & 0 \\ \hat{\alpha}/\hat{\beta}^2 & 1/\hat{\beta}^2 \end{bmatrix}$. The final step requires calculating the matrix product $\mathbf{V_1} = \mathbf{G'} * \mathbf{V} * \mathbf{G}$,

with $\mathbf{V_1}$ the covariance matrix of $\hat{\mu}$ and $\hat{\sigma}$.

A second approach relies on the asymptotic distribution of $\hat{\alpha}$ and $\hat{\beta}$, which is a bivariate normal with means a and b and covariance matrix approximated by **V**. A large number (m) of draws from the above bivariate normal distribution are taken, and for each draw (consisting of two values, one for $\hat{\alpha}$ and one for $\hat{\beta}$) $\hat{\mu}$ and $\hat{\sigma}$ are calculated. Finally, one averages all of the values of $\hat{\mu}$ and $\hat{\sigma}$ thus obtained, and computes the standard deviations of those values. The standard deviations thus calculated provide the standard errors for $\hat{\mu}$ and $\hat{\sigma}$. Confidence

---

[7] At the following website: http://www.ers.uSDA.gov/models/jcooper/ a number of computer programs pertaining to the discrete choice contingent valuation method (CVM) as well the Travel Cost Method (TCM) can be found.

[8] SAS is an exception: its probit routine prints out standard errors for the intercept and slope, as well as the variances and covariance of $\hat{\mu}$ and $\hat{\sigma}$.

limits can be calculated using these standard errors, or by sorting $\hat{\mu}$ and $\hat{\sigma}$ in ascending order, and identifying the 2.5th percentile and the 97.5th percentile of each set (assuming that the desired confidence interval is 95 percent), although bias corrections to this interval may be appropriate (Cooper, 1994).

If elicitation is based on an initial dichotomous choice question, followed by one dichotomous choice follow-up question (the "double-bounded" approach), a likelihood function based on interval data must be specified. To write out the likelihood function, first notice that four possible pairs of responses to the payment questions are possible: (a) yes, yes; (b) yes, no; (c) no, yes; and (d) no,no. Since the follow-up bid amount, B2, is greater than the first for those respondents who answered "yes" to the initial payment question (lower for those respondents who answered "no" to the initial payment question), the pairs identify intervals in which the respondent's WTP amount is assumed to fall.

Specifically, WTP is greater than B2 for "yes, yes" respondents; it lies between B1 and B2 for "yes, no" respondents, and between B2 and B1 for "no, yes" respondents. Finally, WTP is less than B2 for "no, no" respondents. This yields the log likelihood function:

$$(7) \qquad \log L = \sum_{i=1}^{n} \log\left[F(WTP^{H};\theta) - F(WTP^{L};\theta)\right]$$

where WTP^H and WTP^L are the lower and upper bound of the interval around WTP defined as explained above. (Notice that for respondents who give two yes responses, the upper bound of WTP may be infinity, or the respondent's income; for respondents who give two "no" responses, the lower bound is either zero (if the distribution of WTP admits only non-negative values) or negative infinity (if the distribution of WTP is a normal or a logistic).)

Some studies (see for instance Whittington *et al*., 1992) implement an elicitation procedure which includes an initial dichotomous choice payment question, one (or more) dichotomous choice follow-up questions and a final open-ended payment question. This allows the researcher to check whether the follow-up questions have altered the WTP distribution, perhaps by inducing the respondent to make unjustified assumptions about the mode of provision of the good and its quality.[9]

G. Choice of Bids in Dichotomous Choice CV Surveys

As shown in equation (7), and in the formula for recovering the covariance matrix of the original parameters of the distribution of WTP, the standard error around mean or median WTP – and

---

[9] To check for systematic changes in WTP, one can use a Hausman test. To illustrate, assume that WTP follows the normal distribution and consider the estimates of mean WTP based on the responses to the initial dichotomous-choice question, and of mean WTP based on combining the responses to the initial and follow-up payment questions.
Denote the estimate of mean WTP based on the responses to the initial payment question as $\hat{\mu}_1$, with s_1 the standard error around this estimated mean. Denote the estimate of mean WTP from the double-bounded model combining the responses to the initial and follow-up questions as $\hat{\mu}_2$, and its standard error as s_2. The standard error s_2 is smaller than s_1, due to the higher level of information about WTP incorporated in the double-bounded likelihood function. The final step is the Hausman test, which is computed as $H=(\hat{\mu}_1 - \hat{\mu}_2)^2 / (s_1^2 - s_2^2)$. Under the null hypothesis that the mean of the distribution of WTP driving the responses is the same (whether the single-bounded elicitation approach is implemented, or follow-up questions are used), H is distributed as a chi square with one degree of freedom.

hence, the precision of the results from the survey and the power of test of hypotheses about WTP – is crucially affected by the bid values assigned to the respondents as part of the payment question.

Alberini (1995a) and Kanninen (1991) focus on the problem of deriving the bid values that ensure the smallest possible variance around mean WTP (i.e. the so-called "c-optimal" design) when the distribution of WTP is a normal or a logistic. They show that these c-optimal designs are "degenerate," in that they call for assigning the same bid value to all respondents in the survey. This optimal bid value is equal to mean/median WTP. Clearly, such a design does not allow to identify separately the location and scale parameters, μ and σ, of the distribution of WTP.

A related, and feasible, approach is to seek for the values of the bid that minimize the *fiducial* interval around mean/median WTP. The optimal fiducial design requires no more than two different bid values, and assigns respondents evenly and randomly to those two bid values. The two bid values are equal to $\mu \pm z^* \sigma$, with z^* a function of the distribution of WTP one chooses to work with (normal or logistic) and of the sample size. It is clear that this type of design calls for bids that are equidistant from mean/median WTP, and depends crucially on the very parameters of the distribution of WTP one wishes to estimate.

Under ideal conditions, and assuming that the distribution of WTP is a normal, the fiducial design yields an estimate of mean/median WTP that is 63 percent as efficient as that from a sample of equal size and continuous observations. In other words, to obtain an estimate with the same efficiency as that from a sample of continuous observations, one would have to increase the sample size for a dichotomous-choice CV survey by 157 percent (Alberini, 1995a).

Kanninen (1991) examines the use of another design principle, the so-called "d-optimal" design, which seeks to obtain reasonable precision for both mean/median WTP and the standard deviation of WTP, σ. This design also calls for two distinct bid values, symmetric around the mean and equal (for normal WTP) to $\mu \pm 1.1381\sigma$.

Unless good guesses for μ and σ are available prior to the beginning of the survey (perhaps from pre-tests), it is advisable to increase the number of different bid values, and choose bid values that cover a relatively broad portion of the range for WTP. Alberini (1995) finds that deciles of the (presumed) distribution of WTP work well, even when the initial guesses for m and s are poor, Cooper (1993) suggests dividing the distribution of WTP into equal areas, and Boyle *et al*. (1988) suggest randomly generating percentile of the distribution of WTP. If the latter approaches are implemented, implausibly high or low bid values (i.e. amounts that would not be deemed reasonable costs for the commodity or government programme under consideration) should be avoided, lest the respondent fails to take the survey seriously. At any rate, if non-parametric or semi-parametric estimation techniques (Creel and Loomis, 1997) are used to analyse the data, then it would appear to be especially important to choose bid values that cover a relatively broad portion of the range for WTP.

II. Applications of the contingent valuation method to developing countries

In the last few years, the contingent valuation method has been applied extensively to the valuation of environmental quality and to a variety of public programmes in developing countries. Contingent valuation surveys have been administered to obtain residents' WTP for improved water supply in numerous localities of India, Pakistan, Nigeria; to value sanitation (toilets, connections to the sewage system, region-wide waste water treatment) in Burkina Faso (Altaf and Hughes, 1994), Ghana (Whittington *et al*., 1993a) and the Philippines (Choe *et al*., 1996); to place a value to the preservation of national parks in Kenya (Navrud and Mungatana, 1994) and India (Hadker *et al*., 1997), explore setting of entrance fees to national parks in Costa Rica (Shultz *et al*., 1998), and determine priorities for tropical forest protection (Shyamsundar and Kramer, 1996). Applications have, therefore, involved both rural and urban populations.

We are not aware of studies using contingent valuation to value agricultural commodities or pesticide-free produce, but a method related to contingent valuation –contingent behaviour – has been used in Jayne *et al*. (1996) to explore the public's preferences for the stability of agricultural products and food supply. Contingent valuation could be used to estimate WTP to avoid the illnesses typically associated with contaminated drinking water or unsafe food. Finally, contingent valuation could be used to estimate WTP for reductions in the risk of developing cancers and other long-term ailments associated with applying pesticides to crops, with consumption of pesticide-laced produce, or with exposure to pollutants in the air, soil and groundwater. A formidable obstacle to the use of contingent valuation for mortality risk reductions is that respondents must grasp the concept of probability, and refer to events with very small probabilities of occurring, a task that even in the United States and UK has proven extremely hard, and that might be prohibitive in countries with relatively low levels of literacy.

The only application of contingent valuation to estimate willingness to pay for a *public health* programme we are aware of is that conducted in Ethiopia by Swallow and Woudyalew (1994). In this study, people were queried about their willingness to contribute cash and/or labour to the monitoring of a tsetse fly control programme. By contrast, illness treated as a private commodity (e.g., episodes of acute respiratory illness), has been valued successfully in studies conducted in Taiwan (Alberini *et al*., 1997a), and Bangkok, Thailand (Chestnut *et al*., 1998). In the former study, the commodity to be valued had been previously experienced by the respondent and was not framed in a probabilistic sense: The respondent was to experience in a few days a certain recurrence of the episode of illness he had most recently experienced. In the latter study, the researchers chose to focus on one day of acute respiratory illness with varying degrees of severity (a symptom-day, a restricted activity day, and a work loss day).

A. Survey Format and Sampling Frame

Most CV studies in developing countries have relied on in-person, one-on-one interviews conducted by local enumerators, usually trained by an international team. The reason for exclusive reliance on face-to-face interviews is simple: The literacy levels in some developing countries are still too low to permit mail or self-administered surveys, telephones are not available to much of the population (especially in rural areas), and – even when education and telephone connections permit – it is unclear whether the residents of certain developing countries would be willing to participate in mail or telephone survey.[10]

---

[10] There have been reports of difficulties even with in-person interviews: for instance, Shultz *et al*. (1998) find that Costaricans reacted with apprehension to the request of participating in a survey, and may have exaggerated their reported WTP amounts in an effort to impress the interviewers. They contrast such reactions with those of foreign visitors to the two national parks examined in their study, who were very comfortable about participating in the survey.

Lacking listings of residents from which to draw random or stratified samples, researchers wishing to survey residents of urban areas in developing countries have been forced to simply ask interviewers to cover every house in a certain district (or every other house). In some cases, the sampling frame remains unclear. For instance, Hadker *et al*. (1997) report instructing enumerators to interview residents "distributed around Bombay City, at various times of the day and various locations," further stating that "interviewers were instructed to interview a pre-fixed number of high-, medium- and low-income respondents corresponding to bid values."

Ideally, after the sample has been drawn and questionnaires filled out, the researchers should compare the socio-demographic characteristics of the respondents in the sample with those of the population of the area from which the sample was drawn. In most cases, however, the absence of recent official statistics has not allowed to perform such comparison.

Whittington (1998) identifies a number of difficulties when conducting studies in certain developing countries. First, as earlier explained, logistical considerations and the lack of listings for the population from which a sample must be drawn have often forced researchers to limit the sample to relatively small areas (whether in a rural environment or in a large metropolitan area). This has certainly increased the likelihood that respondents may "talk to one another," thus receiving the survey questionnaire with pre-formed judgements influenced by other residents' opinions. Whittington reports that in one instance local neighbourhood officials and chiefs reacted furiously about the survey in progress, to the point of bursting into an interview in progress and trying to influence a respondent's opinions. Whittington concludes that it is imperative to secure the cooperation of local officials and authorities before the onset of the survey to ensure that responses will not be unduly influenced by pressure placed on the respondent or the community's wish to influence the outcome of the study by means of strategic answers.

Second, some respondents in developing countries have struggled with the notion of maximum willingness to pay for a programme or a commodity. Whittington reports that one respondent in Haiti wondered whether "the most he would be willing to pay" meant in the event that a gun was pointed to his head.

Another difficulty is that in some developing areas the quantity of cash available to individuals for them to carry out transactions is very limited, forcing households to refrain from committing to expenditures that are to be incurred on a regular basis. Whittington *et al.* (1992) and Singh *et al*. (1993) conclude that this must be an important reason why households in Nigeria and India, respectively, spend a large fraction of their income to obtain water from vendors during the dry season, but do not wish to commit to the monthly payments that would be necessary if they connected to the city water supply.

Some developing areas still rely heavily on barter and in most access to credit is virtually non-existent, suggesting that very few households can afford the equipment necessary to connect to the city water supply, as is typically required in many cities in developing countries. In one study (Swallow and Woudyalew, 1994), the researchers coped with these problems by asking people how much cash and/or labour they would contribute to receive a public health programme (tsetse fly control). The analysts modelled hypothetical cash and labour contributions as a system of simultaneous equations. However, the language used in that article raises doubts as to whether respondents were taking their financial or labour commitments as unavoidable.

In another article (Shyamsundar and Kramer, 1996), respondents were asked how many bowls of rice they would be prepared to accept as compensation for the loss of access to forest lands annexed to a national park in Madagascar. The use of a WTA compensation measure was necessary because it was felt that respondents stating to be willing to pay to avoid the loss of

access were doing so out of a sense of coercion, and not because they truly has a positive willingness to pay. WTA (in baskets of rice) was found to be correlated with other measures of household wealth and with household-grown crops.

B. Elicitation Format.

Contingent valuation surveys conducted in developing countries have for the most part used a dichotomous choice format, with one or more follow-up questions. In some cases, the sequence of dichotomous choice questions has been closed with a final open-ended question. Whittington *et al.* (1990a) argue that this "bidding game" is well understood and accepted by respondents in developing countries, who, unlike the counterparts in the United States or Western European countries, are used and prepared to negotiating over the price of just about any item they purchase on a regular market. It has not been established how many rounds of bidding questions would be required to produce the best intervals around the respondent's WTP figure. Moreover, no studies have been conducted in developing countries comparing estimates of WTP inferred from open-ended questions with WTP figures from the dichotomous choice approach so frequently implemented.[11]

Whittington (1998) points out a possible problem with the dichotomous-choice elicitation approach, which is likely to arise regardless of the number of follow-up questions used. He notes that the initial bids are varied across respondents, and that even when the sample size is relatively large, respondents in a tightly-knit community may talk to one another about the contents of the questionnaire, and notice that different households have been told about different costs of the plan. This can create confusion about the cost of the programme and result in opposition to the survey, with the resulting downward bias on reported WTP:

"In one community the neighborhood leader dropped in an earlier interview unannounced and heard the referendum price offered to the respondent. This price happened to be the highest of the four prices we used, and the neighborhood leader was quite concerned. He quickly spread word throughout the neighborhood to answer "no" to our valuation question; he felt that the improved water and sanitation programme offered in out CV scenario was simply too expensive at the highest of our referendum prices."

Respondents may also fail to understand that the scenario is hypothetical, and that they should "suppose" or "imagine" the circumstances it describes, warns Whittington, as this is "a nuance often lost in translation." To conclude,

"this illustrates (i) how quickly information can be spread in a close-knit urban community, (ii) how seriously some community members may take the information presented to them in a CV scenario, and (iii) how easily a community can be confused by using different prices and other split-sample experiments."

C. Strategic Considerations in Answering Payment Questions

Much CV research has focused on the possibility of strategic responses to the payment question. Strategic behaviours are said to occur when the respondent alters his *reported* WTP, relative to his true WTP, in order to influence the provision of the good and/or the likelihood of provision of the commodity under investigation. For instance, a respondent who fears he may be asked to pay for the plan may understate his WTP, even though he highly values the plan, while a

---

[11] In developed countries, such studies have led to conclusions in contrast to the theoretical predictions of Hoehn and Randall (1987): WTP estimates from studies using the dichotomous choice approach are often systematically higher than WTP estimates based on open-ended questions.

respondent who wishes for the good to provided, and does not believe he will be made to pay in proportion to his reported WTP, may announce a very large WTP amount.

Strategizing could have been one of the reasons why respondents who were given time to think about the commodity (public water and private connections to the public water supply system) in Nigeria (Whittington *et al*., 1992) had lower WTP amounts than those respondents given a standard interview. Strategic responses may also explain why a more comprehensive plan for sanitation and preservation of surface water quality giving the government a prominent role received lower WTP bids than less broad programmes in a study in the Philippines (Whittington *et al*., 1997).

Some observers (Alberini *et al*., 1997b) have worried that follow-up questions in a dichotomous-choice CV survey may alter WTP by inducing the respondent into believing that the plan being provided by the government is different for different bid values. If this is the case, one would find that mean or median WTP changes systematically as one incorporates into the estimation procedure the information coming from subsequent rounds of questioning. In practice, there has been little evidence of strategic considerations or respondent fatigue that might alter WTP estimates as additional rounds of responses are used. Alberini *et al.* (1997a) find that WTP to avoid an episode of illness reported by a sample of Taiwanese remains very stable with additional rounds of follow-up questions.

Using two groups of respondents, Whittington et al. (1990a) specifically examine the strategic incentives that may influence WTP responses for a programme that would set up public water posts and private connections to the public water supply system in Southern Haiti. Respondents in the first group received the following description of the programme:

I am going to ask you some questions in order to know if you or someone from your household would be willing to pay money to ensure that the CARE Potable Water Project will be successful in Laurent. We would like you to answer these questions at ease. There are no wrong answers.

The water system is going to be managed by a committee of people from Laurent. The committee will be chosen by the people of Laurent. CARE has decided to help Laurent by constructing a water system in this community. Your answers cannot change the fact that CARE has decided to build this water system. CARE never demands money from those people who collect water from public fountains. You will not have to pay money at the public fountains. We need you to tell the truth in order for CARE to construct the best water system for Laurent.

Respondents in the second group received the following description of the programme:

I am going to ask you some questions in order to know if you or someone from your household would be willing to pay money to ensure that the CARE Potable Water Project will be successful in Laurent. The water system is going to be managed by a committee of people from Laurent. The committee will be chosen by the people of Laurent. The committee will decide the amount each household will have to pay to operate and maintain the water system.

Whittington *et al*. argue that on average the WTP amounts reported by persons in the second group should be lower than those reported by people in the first group, because the former respondents would fear that a high bid would result in a higher charge by the community water committee.

The statistical analysis of the WTP responses shows no significant difference between the figures obtained from the two samples. Based on the wording of the payment questions, we believe that only respondents with a high level of sophistication would have been able to grasp the opportunity for strategic behaviour. We also note that the small sizes of the two independent

samples and the large dispersion of the distribution of WTP suggest that the rejection of the null hypothesis of no difference across the two samples is unlikely.

Research by Hadker *et al*. (1997) and Whittington *et al*. (1991) shows that – much like in developing countries – the potential for protest zero responses and disagreement with certain aspects of the scenario (especially those entailing government responsibilities) should not be taken lightly. Hadker et al were forced to ask respondents to imagine that the maintenance of existing quality levels in Borivli National Park would be delivered by an honest, credible, reliable autonomous agency disassociated from the government. Even so, 25 percent of the respondents stated that the "the government should pay for environmental protection," offering evidence that they did not accept (at least part of) the scenario contained in the questionnaire.

Similarly, Whittington *et al.* (1991) report that many residents of Onitsha, Nigeria believe that piped water should be provided for free by the government, and that tension exists between local government agencies, who feel water should be provided at a low price, and donors to investment in infrastructure, who would prefer efficiency pricing to promote conservation. Similarly, residents of Davao in the Philippines (Choe *et al*., 1996) are willing to pay less for a more comprehensive sanitation plan promising preservation of surface water quality at the regional level than for a smaller variant of the plan, probably because of their distrust of the government.

D. Distrusting the Government: Implications for WTP

Altaf *et al.* (1993) examine willingness to pay for piped water in two areas of the Punjab, Pakistan. The researchers selected two regions for their study, one with relatively sweet groundwater, and the other with brackish groundwater. In both regions, households with and without connections to the piped water system were interviewed. In the sweet water region, many households relied on groundwater as their exclusive source of water for drinking, cooking and other domestic purposes, but the use of pumps was common even among households with connections to the piped water system, due to the unreliability of the piped water supply. Both electric and handpumps were frequent, whereas in the brackish water region, electric pumps were necessary to reach deeper and better-quality water.

The survey instrument queried respondents about their WTP only for the most immediate improvement over the current situation: For instance, respondents in villages without private connections to the piped water supply system were asked how much they would be willing to pay for a private connection to a system with level of reliability comparable to the current one, and the a system with improved reliability. Respondents living in villages with piped water were asked to state how much they would pay for connections to a system with improved reliability. Private connections to the piped water system would have to be paid for by household.

Regression analyses show that, as expected, wealthier and more educated respondents have a higher WTP for private connections, and that WTP is higher among residents of the brackish water region. This is consistent with economic theory, in that WTP should be higher in the absence of viable substitutes for the commodity in question (piped water). Interestingly, WTP for systems with improved reliability was lower among those households that were already connected with the piped water system. The researchers speculate that this might be the result of the household's experience, and increased scepticism, with the system itself. The estimated distribution of WTP was used to calculated the expected revenues for the public water authority. The authors' calculations show that cost recovery is unlikely for the sweet water region, unless the authority raises the degree of reliability of the water supply, which in turn secures greater

WTP and higher revenues. In the brackish water region, the expected revenues appear to be sufficient to pay for the cost of the system.

Altaf *et al*. conclude with a description of water supply and policy problems in the Punjab. First, much of the population relies on groundwater for drinking and domestic purposes, but groundwater is being depleted so fast that the water tables are falling rapidly and it has been necessary to rebore wells. Second, the government has not paid much attention to sanitation and water drainage problems. Third, although residents of the brackish water region have a high WTP for piped water, they are often unable to pay up front for the investment required to connect to the piped water system. This suggests that the water authority may wish to devise financing schemes to people connect to the public water system.

The paper concludes that the water supply system in the Punjab appears to be in what Singh *et al*. (1993) describe as a low-level equilibrium trap. Those residents that are already have private connections to the water system pay a flat fee, due to the absence of water meters, and overuse water, forcing the authority to ration the water by periodically curtailing service. In turn, the frequent service interruptions result in low WTP for water, which results in low revenues and diminished ability on the part of the water authority to improve reliability.

Singh *et al*. (1993) examine a similar issue in Kerala, India, a region where a piped water system has been built, with both public taps and private connections, both of which experience a highly unreliable service, forcing residents to supplement the piped water with traditional sources. The alternative water sources and WTP from the villages served by the piped water system are compared with those from a village where a similar type of system has been planned but is not yet operational. Regression analyses show that WTP depends on socio-economic characteristics, including income and education, and on the cost and availability of alternative sources of water.[12]

E. The Demand for Piped Water: Answers for Water Utilities in Developing Countries

McPhail (1994) specifically queried respondents about the reason(s) why they had not yet connected to the piped water system. The reasons most frequently reported by people were that (i) they could not afford it; (ii) they were renters and the landlord would not pay to have taps installed; (iii) they believed their title to the land was affected by some irregularity, and hence the water authority would not provide the individual connection to the system. Finally, some respondents (about nine percent) stated that they lived very close to a public standpipe and did not need an individual connection.

In most cases, respondents purchasing water from vendors or other sources paid a much higher price per litter than they would have if they were connected to the piped water system. It was also discovered that both the reliability of the system and the quality of the water were generally regarded as good, in sharp contrast to the situation frequently encountered in India and Pakistan.

The payment question attempted to find out how high the price of a connection plus water charges would have to be before the respondent would decline obtaining the connection. The survey therefore looks for the choke price, but leaves water consumption unspecified, upon recognizing that it would be too difficult for the respondents to estimate how much water they would demand as a function of water price.

---

[12] Interestingly, the authors find that women do not have systematically higher WTP, despite being the household members that bear the burden of obtaining water. It is possible that for cultural reasons the women interviewed did not feel free to report their own preferences.

The survey data reveal that about 70 percent of the respondents would be willing to pay about TD3 per month, the average bill for connected Tunis residents. This figure is only about three percent of monthly expenditures for the average household in the sample. By contrast, the initial payment required to connect to the piped water system is about TD 52 ($55 in 1994 dollars) and TD77 ($81, in 1994 dollars). The average of these two figures is about 50 percent of the monthly expenditures for the average household, leading McPhail to conclude that it is the down payment for the connection, and not the monthly charges, that discourage most households from connecting to the system.

In Onitsha, a rapidly growing city of 700 000 in the Anambra region of Nigeria, the public water system was built in 1940 and extended in the 1960s. It was, however, damaged during the 1967-70 civil and has since been unable to meet the demands of the growing population. Funding from the World Bank helped build a water supply and sanitation system that was completed in 1988. As in many other parts of Africa, many people in the Anambra region feel that it is the government responsibility to provide water service for free or at a nominal price. The local water authority takes this belief seriously, fearing that people may disconnect from the water supply system if prices are deemed too high or are raised. Should many household choose to disconnect from the water system, revenue would decline and the subsequent ability of the water authority to continue providing a reliable service would be jeopardized.

At the time the Whittington et al study was conducted (Whittington *et al*., 1991), only about 8000 households were connected to the piped water system. The remainder depended on a rather well-organized water vending system based on truck deliveries. The researcher were able to convince the owners of the private truck delivery system to allow enumerators to ride with the truck driver and observe transactions, including re-supply and sales. In addition, households were interviewed from randomly selected blocks in the city.

The interviews uncovered significant differences in water consumption between the rainy season and the dry season, and monopoly rents to the owners of the truck delivery service (who effectively prevented potential competitors from entering the market).

The household survey asked if they would connect to the piped water system and have a meter if the price of water were $X per drum. Follow-up questions were used, determining that residents had a high WTP for water. In fact, many households were already paying a lot for water. Poor households were estimated to pay on average 18 percent of their income on water, whereas wealthy households paid about 2-3 percent of their income on water. Such high WTP suggests that the water authority in Anambra State is not without resources, and indeed has potentially very large revenue.

By contrast, residents of three *rural* communities in Anambra State, Nigeria, simply do not want to commit to monthly charges for water payments (Whittington *et al*., 1990b). Their demand for publicly provided water is seasonal, as households collect the abundant rainwater during the wet season to provide for drinking, cooking, bathing and other domestic purposes. Rainwater is generally regarded as of good quality. During the dry season, households are forced to collect water in other ways, and at a high time cost. Depending on the village, it takes on average four to seven hours a day to collect water. Whittington et al estimate that on an annual basis households in the Nuskka district spend between 6 and 10 percent of their income on water, and incur water expenses of $5-8 per month during the dry season, an amount comparable to that of households in industrialized countries, who receive much more water and a much more convenient service for the same expenditure.

The questionnaire described two types of commodities: Public taps and private connection to an improved water supply at various monthly rates. Willingness to pay figures were

systematically related to income and socio-demographics, but were very low, and – a perplexing result – in fact *less* that what households were already paying to obtain water.

After re-interviewing some of the respondents, the authors conclude that the puzzling findings are likely due to three reasons. First, during the dry reason employment in agriculture virtually disappears. Residents simply do not have the cash flow to commit to fixed monthly payments, as would be required by connecting to the piped water system. Since there is not much employment in the summer, the value of time is very low, and residents can afford to spend many hours a day collecting water. Second, residents are not likely to have a good feel for their total expenditures on water during the dry season, since purchases from vendors and trucks do not take place at regular intervals. Third, many respondents indicated that they felt that they were entitled to free or subsidized water and that it was the government responsibility's to provide their village with a new water system. Based on this last point, the researchers concluded that willingness to pay may be influenced by political or non-economic factors, and that households' sense of entitlement and equity may be a major obstacle to cost recovery for the water authority.

Based on these studies, the World Bank (1993) suggests that the demand for improved water supply in developing countries can be placed into four different categories. The first category is comprised of villages and towns where households have a high WTP for private connection but a low WTP for public taps, a symptom of the presence of "low-level equilibrium trap." Here, the suggestion is to offer private connection with meters and improved reliability, charging people more for water and breaking the pattern of overuse (due to the fact that the marginal cost of water is zero), excessive load on the system, and interruptions to ration water.

The second category is comprised of villages and areas where the majority of residents will pay for the full cost of public taps, but only few will pay for the full costs of private connections. Provision of public taps will decrease the demand for private connections, but some charge must be levied to public tap users to generate the revenues necessary to sustain the system. One approach here is to establish a system of public kiosks charging the full cost of water by the bucket, along with allowing households that wish private connections to obtain such connections, which should be fully metered.

The third category of villages and towns are those where residents are willing to pay for improved service, but the cost of providing such improved service is too high. This happens mostly in arid and poor areas of Africa and Asia, and it is not easy to design policy mechanisms that can address this problem. Finally, the fourth and last category includes villages and towns where WTP for improved service is very low. As unappealing as this may sound, Whittington et al recommend that decisions on how to provide improved service be deferred until changes in taste or income result in the suitable WTP level. These considerations would suggest that for the most part the role for benefit transfer in developing countries is relatively limited, at least when the commodity under investigation is he provision of water to residences by a government agency.[13]

To summarize, most studies of WTP for improved water supply found varying level of WTP, depending on the cost of obtaining water from alternative sources, respondent income and education, the expectations the respondents were likely to form about the quality and reliability of the service to be valued, and on their ability to commit to specified forms of payments taking place on a regular basis.

---

[13] As can be seen in section II.I, benefit transfers may be feasible when the commodity to be valued is a private good, such as a health endpoint.

F. Substitutes for the Good Being Valued and Respondent Socio-demographics

Economic theory suggests that WTP for a good should increase as the cost of purchasing substitutes for that good rises. When the good to be valued is a connection to the public water system, one would expect that households facing high monetary and time costs for alternative water sources would hold high values for piped water. In practice, this has confirmed true in some studies and has been refuted in others.

In the studies about the provision of piped water reviewed in this report, household expenditure to purchase water ranged from 2 to 18 percent of income, depending on location, sources of water available to the populace, and household income. However, some studies (including Whittington *et al*., 1990b) found that even at locations where such expenditure was a relatively high fraction of household income, people's WTP for piped water was surprisingly low. Among other reasons, this was explained by the seasonal nature of water scarcity, which left respondent lukewarm to the idea of committing to monthly payments for a connection to the water supply system, especially in view of the restricted nature of the local labour market and wage cash flows.

Researchers have also hypothesized that women, who bear most of burden of obtaining water in the absence of piped water systems or pumps for groundwater extraction, should hold greater WTP figures. This hypothesis is borne out in some, but not all of the studies, perhaps because women in many developing countries have little control of the household finances and may refrain from expressing their own opinions for cultural reasons (Singh *et al*., 1993).

At some study locations, income was very difficult to measure, because of reliance on barter and/or the respondents' reluctance to reveal information about their income. This has sometimes forced researchers to ask enumerators to note information about the size, construction quality and fixtures of the respondent's home, or to take down the number of appliances at the respondent's home. From such information estimates of household wealth were produced.

When information about respondent income is available, it is possible to include income (or a transformation of this variable) among the independent variable of the econometric regression equation for WTP, and to calculate the income elasticity of WTP. Alberini *et al*. (1997a) find that for the Taiwanese involved in their study the income elasticity of WTP to avoid minor episodes of acute respiratory illness is 0.4, a figure that is consistent with the findings from similar studies in the United States (Loehman et De, 1982).

G. Comparing CV and Other Valuation Approaches

We are aware of two studies in developing countries that have checked for convergent validity of the estimates of WTP from a CV survey. In both studies the comparison is with the welfare figures from a companion travel cost study.

The first of these two studies examines surface water quality improvements. Choe *et al*. (1996) recognize that sanitation in developing countries evolves through three stages. At the first stage, people remove excreta and wastewater from their own homes, thus improving hygiene within their dwellings, but potentially deteriorating that of their neighbourhood. At the second stage, sewer lines are built to collect wastewater away from ditches and neighbourhood street. Unless wastewater treatment plants are built, however, as typically happens in stage 3, untreated sewage is released or spills into surface water bodies.

Choe *et al*. interviewed the populace of Davao in the Philippines about each of these stages. Since raw sewage ends up contaminating local beaches and diminishing the enjoyment of such

beaches for Davao residents, the authors combined a contingent valuation survey with travel cost estimates of the losses suffered by residents due to beach closures or "no swimming" advisories at Times Beach.

The sample to which the CV survey was administered was stratified by ownership of a water closet in the home and home ownership. Specifically, the authors formed three groups of subjects: The first group includes households that own their homes and have a water closet; the second includes renters; the third includes households that own their homes but do not have a water closet for their exclusive use, households that own the home but do not have title to the land, and households who occupy a house with the owner's consent but do not pay rent.

Households in group 2 and 3 and part of the households in group 1 were told about an unspecified city-wide plan that would cleanup rivers and sea and make Times Beach available for swimming and recreational activities. This would imply a monthly cost to the household; the industry would also commit to reduce discharges into rivers. Essentially, this scenario involves an improvement from stage 2 to stage 3. The other households in group 1 were told about a more comprehensive plan involving construction of sewer lines and wastewater treatment plants, as well as cleanup of rivers and sea. This is a plan making the transition from stage 1 to stage 3. Since the government programme described to the latter households is broader than the previous one, it is expected that WTP should be greater than WTP for the river and sea cleanup plan.

The analysis of the responses indicated that people were generally well aware of the deterioration in water quality experienced at Times Beach over the last few years and the decline in beach attendance due to the pollution problems, and had indeed heeded the pollution advisories. Willingness to pay for the plan increased with household income and respondent educational attainment, and is typically higher for respondents who had used Times Beach before the health advisories (and hence experience losses of recreational uses). Mean WTP for the smaller of the two programmes is about 27 pesos per month (or $1.08). Mean WTP for Households who did use Times Beach prior to the health advisories is twice as much as that of households who did not go to Times Beach. In addition, the responses pass the "scope test:" Willingness to pay is significantly greater, the more comprehensive the programme to be valued by the respondents.

The authors further estimate a single-site travel cost model based on information reported in the survey.[14] The dependent variable of the econometric equation is the number of annual

---

[14] The travel cost method (TCM) has been used extensively to place a value on environmental amenities, such as national parks, fishing and hunting sites, etc. In short, this method assumes that each trip to the destination of interest costs money to the person undertaking the trip, the price of a trip being comprised of transportation costs (e.g., gasoline in the case of automobile travel, or airplane fare), food and lodging, admission to the site (if any), fishing or hunting license fees, plus the opportunity cost of the time spent traveling to and at the site, which should depend on the person's income. For a given site, the price of a trip varies across visitors, because of their different incomes and the different distances from the site. It is assumed that trips and quality of the site are weak complements, the former being an increasing function of the latter. A single-site study thus fits the following econometric equation: $r = f(p_r, Q; X)$, where *r* is the number of trips undertaken by the respondent in a specified time frame (a year, or a fishing season), p_r is the price of a trip, Q is site quality, and X is a set of respondent characteristics (e.g. gender or family status) thought to influence visitation rates. The estimate equation yields a Marshallian demand function, which can be used to approximate the welfare change associated with changes in certain parameters, such as the fishing license fee, which in turn influence p_r. In practice, when estimating TCM models, one needs to control carefully for the population of interest (i.e., for participation in the activity of interest, which can change as p_r does), and for the presence and cost of visiting substitute sites. Additional data are necessary when one wishes to compute the welfare change associated with changes in quality (instead of changes in p_r) at the site.

visits to Times Beach by the household. The independent variables include (i) round-trip travel costs to the Times Beach site (including the opportunity cost of time); (ii) a dummy variable capturing water quality before and after the advisory was issued; (iii) annual income; (iv) head of household's education level; (v) respondent's age; (vi) a dummy describing whether the household lives in a *poblacion*; and (vii) travel costs to a substitute site.

The consumer surplus loss associated with the health advisories was estimated to be about 51 pesos, which is to be contrasted with a mean WTP of about 30 pesos from users of Times Beach. The authors conclude that contingent valuation and travel cost approaches yield estimates of WTP of similar magnitude, and offer some explanations as to why the two estimates may be somewhat different.

Similar results about the consistency between CV-produced values and travel cost estimates are reported in Navrud and Mungatana (1994), who use the value of recreational wildlife viewing at Lake Nagaru National Park, an area noted for its large population of lesser flamingos, as a conservative lower bound to the total economic value of wildlife viewing. This study uses a random sample of park visitors, one-third of whom were residents and two-thirds of whom were foreign visitors, mirroring the composition of park visitors on an annual basis. Both WTP and travel cost estimates were calculated separately.

The conclusions of the Choe *et al*. and the Navrud and Mungatana studies are comforting and consistent with a large body of literature in developing countries (summarized in Carson *et al*., 1996), showing that CV produces values similar to those obtained by the travel cost method or other approaches based on actual behaviour.

H. The Challenge of Describing the Commodity to the Respondents

In general, CV practitioners wishing to estimate WTP for improved sanitation services have faced difficulties explaining respondents how improved sanitation will be attained and the (physical and aesthetic) benefits improved sanitation will bring. Altaf and Hughes (1994) experiment with a somewhat different approach to the task of describing the commodity to respondents in Ouagadougou, Burkina Faso. This urban area lacks sewer systems. WC toilets, when available (12.5% of the households interviewed), feed into septic tanks. Pit latrines are available (over eighty percent of the sample), but none is of the ventilated, improved type or pour type. Lack of familiarity with the improved technologies prompted Altaf and Hughes to describe the attributes of the technologies that would be relevant to the respondents, rather than the technologies per se. For instance, improved latrines were described as follows:

> There exists an improved latrine that has been introduced and is working satisfactorily in other countries. The principal characteristics of such an improved latrine are the following:
> 1. It is odour- and fly-proof.
> 2. It is permanent and can be installed inside the house, if desired.
> 3. It does not require a piped water connection for operation.
> 4. The excreta are transformed through a natural process into compost which is not harmful to health.
> 5. The pit needs to be emptied very three years. It can be emptied manually without having to touch fresh excreta.
> 6. Household wastewater can be disposed of in this system.

The characteristics describing a WC system and off-site service are:

> There is another type of improved sanitation with the following principal characteristics:

1. It is odour- and fly-proof.
2. It is permanent and can be installed inside the house, if desired.
3. It requires a water closet for operation.
4. It requires a piped water connection for operation.
5. The household does not need to dig or empty pits. The excreta are taken away from the neighbourhood for treatment through underground pipes.
6. Household water can be disposed of in this system.

Renters were to pay the charges for such services in the form of higher rent. Owners were entitled to pass some of the extra costs to their tenants, if any.

Although the analysis of the responses from this survey was not, in our judgement, very sophisticated from a statistical modelling point of view, it nevertheless provides interesting insights about the preferences for sanitation in this community. Mean WTP is 345 F CFA per month for wastewater disposal; 953 F CFA per month for on-site sanitation, and 1462 F CFA per month for off-site sanitation. This amounts of about 4 percent of household income, a percentage that is higher than that uncovered in a study of Kumasi, Ghana, residents. In addition, the higher the current level of sanitation and wastewater disposal available to the household, the greater WTP for the next degree of improvement. This implies that marginal WTP is increasing.

Of the respondents that decline to pay the amounts suggested to them as part of the dichotomous choice payment question procedure, many stated that they were dissatisfied with having to commit to regular payments forever.[15] Calculations by the authors assuming a capital cost of 50 000 F CFA for a new on-site facility suggest that the payback period for this investment would be only four or five years.

While the authors do not report much about the acceptance of their approach to describing sanitation improvements to respondents, study participants were shown photographs of ventilated improved pit and pour flush latrines towards the end of the questionnaire administration. Assuming that the cost of the two technologies were the same, most people preferred the pour flush for hygienic, convenience and modernity reasons.

A more conventional description of the commodity to be valued was adopted by Whittington *et al*. (1993b), who queried respondents in Kumasi, Ghana, about five different levels of sanitation improvements: (i) Kumasi ventilated improved latrines; (ii) WC with sewer connections; (iii) sewer connections for households who already had WCs and septic tanks; and, for household currently without water connections, (iv) private water connections and (v) private water connections plus WC with sewer connections. Respondents were asked to report their WTP only for immediate improvements over their current situation.

The authors find that WTP is well correlated with individual characteristics, and with the convenience of the sanitation alternative. For instance, residents of multi-story buildings bid on Kumasi improved ventilated latrines less, presumably because of their inconvenience to occupants of higher floors. What is even more interesting in this study is that the researchers experimented with altering the conditions under which respondents were to make decisions about their WTP figures. Specifically, a subset of the respondents were given time to think about their WTP before they had to declare WTP to the enumerators. In contrast to an earlier study by Whittington *et al*. (1992) which concluded that giving respondents time to think

---

[15] Similar types of concerns were voiced by respondents in a study on water supply provision in rural areas of Anambra state, Nigeria (Whittington *et al*., 1990b).

typically lowered their WTP bids, in the present study no systematic effects were associated with more or less time to think. (The only instance in which some effect was noted was when analysing WTP for sewer connections by households with WCs. In this case, as expected on the grounds of the results of the previous Whittington *et al.* study, giving respondents time to think reduced their WTP.) The researchers also checked whether the presence of other household members altered people's WTP, but found no evidence bias induced by the presence of other people present at the interview.

I. Valuing Health for Policy Purposes

When estimating the health benefits of a proposed policy reducing pollution or imposing workplace environmental regulation, it can be shown that a person's willingness to pay to pass the policy is comprised of four distinct components, capturing the changes in (i) medical expenditure, (ii) work income lost to illness; (iii) expenditures incurred by the individual to reduce pollution exposures; and (iv) the value of the discomfort associated with illness.

To illustrate, assume that an individual's well-being increases with aggregate consumption (X) and leisure (L), but is negatively affected by sick days, D:

$$(8) \qquad U = U(X, L, D; Z_u)$$

where U is increasing in X and L, and decreasing in D, and Z_u is a vector of individual characteristics capturing preferences for income, leisure and health.

In this model pollution, P, does not influence utility directly, but only indirectly by triggering illness. The relationship between pollution and health outcomes is summarized into a dose-response function: $D = D(P; Z_D)$. The dose-response function can be amended to accommodate for averting activities, A, undertaken by the individual to reduce exposure to pollution, and hence illness:

$$(9) \qquad D = D(P, A; Z_D)$$

where it is assumed that $\partial D / \partial A$ <0 and $\partial D / \partial P$ >0. We include a vector of individual characteristics, Z_D, among the arguments of the dose-response function to allow for individual predisposing factors and baseline health, and because the ability to offset exposure to pollution through averting behaviour is likely to vary across individuals.

The individual chooses the levels of L, X, and A to maximize utility, subject to the budget constraint:

$$(10) \quad y + w[T - L - W(D(P, A))] = X + p_M \cdot M(D(P, A)) + p_A \cdot A$$

Equation (10) assumes that the individual must allocate his time between work and leisure, and spend income on aggregate consumption and medical care, M, which in turn depends on the number of sick days, and on the averting activity. The prices of M and of A are equal to p_M and p_A, respectively, whereas the price of a unit of the aggregate consumption good is normalized to one. Sick time enters in the budget constraint because it reduces work time available to the individual. In equation (10), work time lost to illness is denoted by W(·).

Willingness to pay for environmental quality. An individual's willingness to pay (WTP) for a reduction in pollution is the amount that must be taken away from the individual's income while keeping his or her utility unchanged:

(11) $$V^*(y - WTP, w, p_m, p_a, P_1) = V^*(y, w, p_m, p_a, P_0)$$

where V* is the indirect utility function, and P_0 and P_1 are the initial and final levels of pollution ($P_0 > P_1$, *i.e.*, environmental quality is improved).

Following Harrington and Portney (1987), it can be shown that WTP for a small change in pollution can be decomposed into:

(12) $$WTP = w\frac{dW}{dP} + p_m\frac{dM}{dP} + p_a\frac{\partial A^*}{\partial P} - \frac{U_D}{\lambda}\cdot\frac{dD}{dP},$$

where A* is the demand function for A, and $\partial A^*/\partial P$ gives the optimal adjustment of A to a change in pollution. Equation (12) states that marginal willingness to pay is comprised of marginal lost earnings and medical expenditures, and of the marginal cost of the averting activity. In addition, willingness to pay includes the disutility (discomfort) of illness, converted into dollars through dividing by the marginal utility of income.

Equation (12) can be re-arranged to produce:

(13) $$WTP = \frac{dD}{dP}\cdot\left[w\frac{dW}{dD} + p_m\frac{dM}{dD} + p_a\frac{dA^*}{dD} - \frac{U_D}{\lambda}\right],$$

showing that marginal WTP can be expressed as the product of the slope of the dose-response function, times the marginal value of illness (the quantity in brackets).

This has two important implications for valuation work: First, following equation (13), WTP for a reduction in pollution could be computed by asking individuals to report their WTP to avoid illness per se (without implicating pollution), and then blending such WTP figures with epidemiological evidence, summarized into dD/dP.

Alternatively, one may turn to the components of WTP in the right-hand side of equation (12). In practice, however, researchers following this second approach have focused on estimating only *some* of these components of WTP using revealed preference data, due to the obvious difficulty of measuring the value of the disutility of illness.

Need for WTP Estimates in Developing Countries. In recent years, local and country governments in developing countries have increasingly needed information about the costs and benefits associated with reduced levels of pollution to assist them in setting (or revising) standards and imposing pollution control measures.

To determine the value of the damages to health (both morbidity and mortality) due to air pollution, analysts have traditionally relied on concentration-response functions linking pollution levels to health effects in the population (as in equation (9)), and estimates of willingness to pay to avoid such effects.

For lack of original studies in the countries where the benefits are to be estimated, analysts have sometimes resorted to extrapolating concentration-response functions estimated in the United States to the levels of pollution in the target country (Ostro, 1994). This approach has been criticized as potentially invalid on the grounds of the different cultural, behavioural and institutional circumstances, and of the difficulty of finding places with matching environmental conditions from which predictions can be made for the target country.

Similar techniques have been applied to produce WTP figures, after adjusting for the income differential between the two countries (Krupnick *et al*., 1996). Two recent studies, however, have questioned whether this approach is satisfactory, showing that willingness to pay to avoid illness can be higher in Taiwan and Thailand than one would expect from extrapolations from United States studies (Alberini *et al*., 1997; Chestnut *et al*., 1998).

The Taiwan Study: The Prospective Cohort Study. Taiwan is a newly industrialized country with 1992 per capita income of about $10,000 (about one-half of per capita income in the United States), and with no prior original epidemiological and valuation work to uncover the health benefits of reducing air pollution.

For 92 days from November 1991 to January 1992, respondents in the cities of Taipei, Kaohsiung, and Hualien in the Republic of China (Taiwan) filled out a diary to record the presence/absence of 19 minor respiratory-related symptoms (chest discomfort, coughing, wheezing, sore throat, cold, flu, and others) and symptoms linked to pollution exposures (headache and eye irritation). Respondents were also asked about the severity of these symptoms, and about activities undertaken to alleviate symptoms (such as seeing a doctor) and the related expenditure.

The diaries' data were matched with pollution and meteorological readings taken at a monitor located within 750 meters from the respondent's residence (for a total of 5 monitors), and with information about the respondent's socio-demographics and chronic health conditions (if any), resulting in a panel dataset containing 87676 observations (953 respondents times 92 days). Participants were selected by random sampling after stratification by age, with the sample including both children and adults.

The levels of particulate matter of diameter less than 10 microns (PM10) measured at the five monitors varied widely from one to the next and across sites. They were very high at the Sun-San monitor in downtown Taipei, and at the two Kaohsiung locations, Sun-Min and Fu-Hsing, where the Taiwan standard of 125 mg/m^3 was frequently exceeded. Ozone, sulphur dioxide and nitrogen dioxide readings were very low and well below both Taiwan and comparable United States ambient standards.

Perhaps the most surprising finding from the health diaries was that illness rates were extremely low. Almost one-half of the Taiwanese made it through the study period without experiencing any of the symptoms under investigation. On the average day, only 4.6 percent of the adults experienced one or more symptoms. The most commonly reported symptoms were cold and flu, followed by cough with phlegm, runny nose, sore throat, dry cough, and headache. Wheezing, allergy and asthma attacks were rare. Doctor visits, use of medication, and work days lost to illness were rather infrequent: on any day of the study, 1.5 percent of the respondents reported seeing a doctor, a similar percentage took prescription medication, and less than one percent stayed home from work.

Despite such low illness rate, Alberini and Krupnick (1998) find a positive and significant relationship between PM10 and respiratory symptom-days. The probability of beginning a new episode of illness *is* related to PM10 levels, even after one controls for temperature, relative humidity and other factors potentially influencing illness. The effect of PM10 is significant for both non-infectious symptoms and infectious (i.e., viral and bacterial) illnesses, supporting the hypothesis that PM10 can both impair the immune system's response to infection, and irritate the airways, interfering with normal respiratory functions. The effect of PM10 varies dramatically across groups of subjects, with non-smokers, males, 30-plus-year-olds and persons not subject to occupational exposures to fumes and dust the most sensitive.

Among persons that do not suffer from a chronic respiratory illness, the expected incidence rate is 1.1% when fine particulate matter is 150 μg/m^3 and 1.87% when the PM10 level is raised to 300 μg/m^3. These figures are much lower than the predictions obtained from a similar model, fitted to daily data from a study conducted in Los Angeles area in 1979 (see Alberini and Krupnick, 1997). Specifically, the predicted rates for Taiwan from the Los Angeles concentration-response function are 4.87% and 5.51%, respectively. Finally, while PM10 levels influence the onset of illness, they do not affect the duration of the episodes of illness, once they start.

The Taiwan Contingent Valuation Survey. About nine months after the completion of the diaries study, respondents were recontacted and asked to participate in a contingent valuation survey about their most recent episode of acute respiratory illness. The questionnaire was administered to the respondent in face-to-face interviews conducted by professional enumerators.

Respondents were first to describe their most recent episode of illness by (i) checking which of the symptoms listed on a card they had experienced; (ii) reporting the duration (in days) of each symptom on a time line; (iii) answering questions to further identify the nature of the illness and its seriousness (for instance, was the illness a cold, or the flu?); and (iv) reporting medical visits and expenditures, as well as restrictions in daily activities and the related costs. Pollution was never mentioned to the respondents in this portion of the study.

Finally, respondents were asked to imagine that they were about to experience, in a few days, a similar illness. How much – the questionnaire asked them – would they be willing to pay to completely avoid a recurrence of such an episode of illness? To facilitate their answers, the question was re-phrased using the dichotomous-choice format. To refine information about WTP, two follow-up questions followed their "yes" or "no" answers to the initial payment question.

This approach to eliciting WTP to avoid illness is different from that used in previous studies in the United States (Loehman *et al*., 1979; Loehman and De, 1982; Tolley *et al*., 1986), in that the commodity to be valued is defined by the respondent, as opposed to being defined for the respondent by the researcher ("Imagine experiencing a severe cold that lasts for 4 days…"). This has both advantages and disadvantages. An advantage is that the respondent is familiar with the illness, and that reported willingness to pay reflects mitigating behaviours.[16] For large sample sizes, the distribution of illnesses experienced by the respondents in the sample should be close to that of the population.

A disadvantage is that the WTP data may be affected by errors-in-variables and/or heteroskedasticity, depending on the quality of the respondent's recall of the episode of illness. Although the survey instrument places a relatively heavy burden on the respondent, focus groups conducted at various stages of the development of the survey instrument suggested that focus group participants generally accepted the questions and were relatively comfortable with the hypothetical nature of the payment question.

Alberini *et al.* (1997a) fit interval-data models to the responses to the payment questions and follow-ups, finding that WTP to avoid an episode of illness is well predicted by the episode's (i) duration, (ii) number of symptoms and (iii) nature (a cold or otherwise), and by the respondent's (iv) education, (v) income and (vi) baseline health. The income elasticity of WTP

[16] To elaborate, Alberini *et al*. (1997a) argue that respondents should be informed of opportunities for mitigating behaviour when valuing illness. Willingness to pay to avoid a headache should be lower if the respondent knows that the discomfort and pain of the headache can be mitigated by taking an aspirin.

is approximately 0.4; respondents suffering from a serious respiratory illness hold WTP values that are 39% higher than those of healthier respondents, and respondents with a chronic non-respiratory condition have WTP that are 46% greater than those of non-chronic subjects.

The estimated coefficients of the WTP equation remain stable when estimation is restricted to the responses to the initial payment question, or to these plus the responses to the first round of follow-ups.

Median WTP to avoid an average illness (one that lasts 5.3 days, entails 2.2 symptoms) is NT$980, or $39.20 US dollars (1992 dollars). There is a considerable degree of variation in WTP, depending on the length and seriousness of the episode one considers. Specifically, WTP increases with the duration of the episode, but a decreasing rate: avoiding the first day of a cold is worth $20.45, but avoiding the entire 5.3-day episode is worth $34.62, for an average WTP per day of $6.53.

To assess the appropriateness of benefit transfer procedures, Alberini et al. select two studies from the United States by Tolley *et al*. (1986) and Loehman *et al*. (1979), and extrapolate the dollar figures from these studies, focusing on a one-day head cold, and adjust these figures for income to produce predictions for Taiwan. They use two alternative formulae:

$$WTP_{TAIW} = WTP_{us} \cdot \frac{\text{income of Taiwan sample}}{\text{income of US sample}}, \tag{14}$$

$$WTP_{TAIW} = WTP_{us} \cdot \left(\frac{\text{income of Taiwan sample}}{\text{income of US sample}} \right)^{\alpha} \tag{15}$$

where α is the income elasticity of WTP in the Taiwan sample (0.4). Formula (14) thus presumes that the income elasticity of WTP is 1.

If the illness day here considered causes restrictions in daily activities, the dollar figures from the original United States studies and for Taiwan can be summarized as shown in Table 1.

Table 1. Benefit transfer comparisons for WTP for one-day head cold. All figures are expressed in 1992 US dollars

	WTP in original study	Prediction for Taiwan (α=1)	Prediction for Taiwan (α=0.4)	Actual WTP from Taiwan study
Tolley *et al.* (1986)	40.32	28.07	34.88	20.45 (95% confidence interval: 16.31, 27.29)
Loehman *et al*. (1979)	19.23	16.37	18.06	

Source: Alberini *et al*. (1997a).

This shows that the WTP figure from one study would overpredict WTP for Taiwan, while the WTP figure from the other study underpredict WTP for Taiwan, but would fall within the 95% confidence intervals around the point estimate for the latter. One can also reverse the comparison, using the WTP from Taiwan to predict WTP for the United States. This approach yields prediction for the Tolley et al sample of $62.12, with 95% confidence interval of $26 – $98. The confidence interval thus covers the point estimate from the Tolley study, which is $40.32. Based on these comparisons, one can neither confirm nor rule out the appropriateness of benefit transfers.

Alberini and Krupnick (1997, 1998) combine the illness rates predicted by the epidemiological concentration-response function for Taiwan with WTP to avoid illness estimated

from the CV part of the study, showing that the benefits of reducing particulate matter levels from an initial 150 μg/m^3 to 135 μg/m^3 would entail expected benefits of $265 476 (1992 US dollars) to the adult populations of Taipei, Kaohsiung, and Hualien (for a total adult population of about 3 million). A larger reduction to 120 μg/m^3 would imply morbidity benefits of $519 177, while lowering PM10 from 300 μg/m^3 to 150 μg/m^3 would produce health benefits worth $3.393 million. For benefit transfers from the Los Angeles study, the Los Angeles concentration-response function tends to overpredict illness rates for Taiwan, while United States WTP figures tend to either overpredict (the Tolley *et al*. study) or slightly underpredict (the Loehman *et al*. study) the Taiwan figures. The net effect of extrapolating the morbidity benefits of a reduction in air pollution from Los Angeles to Taiwan is that the latter tend to be overstated.

Comparison between WTP and the cost-of-illness approach. The Taiwan study also allows one to compare WTP to avoid illness with the cost of illness (the sum of medical expenditures plus work income lost to illness). This comparison is useful for three reasons: First, it acts as a validity check for the WTP figures reported by the respondents in the contingent valuation survey. As seen earlier, economic theory posits that WTP to avoid illness should be greater than cost-of-illness measures, which represent a lower bound for WTP. Assuming that the CV study has been correctly designed and implemented, one would then expect estimated WTP to be greater than cost-of-illness figures.

Second, since cost-of-illness figures may in some instances be obtained from official statistics, and may be easier and less expensive to obtain than survey-based WTP data, if one knew – at least approximately – what fraction such costs represent of total WTP, one would be able to obtain a rough estimate of the health damages of air pollution by multiplying the cost of illness by the inverse of that fraction. Third, given the differences in cost and availability of medical care, sick leave systems and perception of illness between western countries and developing countries, it is of independent interest to see if WTP to avoid illness is, in Taiwan, as large a fraction of the total damages as it is in the United States.

It is widely recognized that the cost of illness provides only a lower bound for the correct measure of willingness to pay (Harrington and Portney, 1987). The few empirical studies that have directly queried individuals about their willingness to pay to avoid illness, and have compared WTP with cost-of-illness figures incurred by the same subjects for comparable illnesses, have found that WTP is 1.6 to four times larger that the sum of expenditures and income loss, suggesting that the value of the discomfort caused by illness can be quite large, at least for populations in the United States (Rowe and Chestnut, 1985; Chestnut *et al.*, 1988; also see Dickie and Gerking, 1991).

Alberini and Krupnick (2000) find that the ratio of WTP to COI ranges from 1.48 at very low levels of particulate matter to 2.26 at the highest PM10 readings (350 μg/m^3). The ratio increases with particulate matter levels, because as pollution worsens people experience more symptoms, but their doctor visits, prescription medication expenses and lost earnings do not increase proportionally. These numbers are consistent with economic theory, which predicts that WTP to avoid the health effects of pollution is greater than the cost-of-illness measure. It is surprising that despite economic, cultural, and institutional differences between the United States and Taiwan, the WTP/COI ratios for the Taiwanese are in line with similar ratios computed for the United States.

The Bangkok Study. Another study eliciting TP to respiratory symptoms of varying severity was conducted by Chestnut *et al.* in Bangkok, Thailand, in April 1996. The sample who was given a contingent valuation survey questionnaire had previously participated in a prospective cohort study (from December 1995 to April 1996), and had recorded the presence or absence of

respiratory symptoms on a daily basis.[17] The purpose of the diaries was to relate the respiratory symptoms and their severity to the fluctuations of air pollution (and especially particulate matter) in Bangkok. Subjects were recruited among adult resident of the Odean Circle area and nurses working at a local hospital who lived in nurse dormitories near the hospital. Children were also followed as part of the epidemiological study, but were excluded from the CV survey. All subjects were selected among the residents of area near air quality monitors, and the sample cannot be assumed to be representative of the population of Bangkok.

Chestnut *et al*. followed the traditional approach of querying individuals about their WTP to avoid a "symptom day" (which created no particular restrictions to work or other daily activities), a "restricted activity day" (during which subjects curtailed some of their activities, but did not necessarily miss work or spent the day in bed), and a "work loss day." As earlier mentioned, economic theory shows that a lower bound for WTP for each of these health endpoints can be obtained using the "cost-of-illness" approach – i.e. by summing together the medical expenses and loss of work income (if any) incurred by the individual. Indeed, Chestnut *et al*. queried respondents about their expenditures on medication and remedies, and found out that these were negligible. By contrast, WTP to avoid each of the endpoints was relatively high: mean WTP for a symptom day was $16 (1996 US dollars), for a restricted activity day was $30 and for a work loss day was $63. Median WTP was $4, $12 and $24, respectively. Chestnut *et al.* compare these figures with those provided by selected studies in the United States, and find that even without adjusting for income differential across the two countries the pairs of WTP figures are remarkably similar, since mean WTP for a comparable endpoint in the United States is (in order) $11, $26, and $99 to $189.

Since household and per capita income in Bangkok are approximately one-quarter to one-third of their United States counterparts, these findings suggest that Bangkok residents place relatively high value of avoiding respiratory symptoms. The figures obtained in the study also compare well to those obtained by Alberini *et al.* for a typical episode of respiratory symptoms.

In the Chestnut *et al*. study, WTP was elicited using the payment card approach. This is the only application of this elicitation approach that we are aware of in a developing country. Chestnut et al report that a number of people reported WTP equal to zero. Many of these respondents, however, are argued to truly place a value on avoiding illness, but to "protest" (or simply fail to understand) the trade-off between income and health implied in the contingent valuation exercise. "Protest zeros" were excluded from the usable sample, which in the end included only 141 respondents. Chestnut et al were unable to check for the relationship between income and WTP, because the income variable was affected by too many missing values, but found that nurses had lower WTP values for avoiding the mentioned health endpoints.

J. The Effects of Giving Respondents Time to Think

In 1992, Whittington *et al*. published an influential paper reporting the results of a split-sample experiment incorporated into a contingent valuation survey eliciting WTP for public taps and private connections to the water supply system in Nigeria. While one independent subsample of respondents was given the questionnaire following the usual protocol, the other was asked to go home, discuss matters with family members and neighbours and answer the payment question overnight. The respondents in the former group were also re-interviewed at a later time to determine the likelihood of WTP revisions, as well as the magnitudes of those revisions.

---

[17] In this sense, the Bangkok study is similar to the Taiwan study.

The results were astounding: For both commodities, those persons who had had time to think about the commodity reported systematically *lower* WTP amounts. The researchers ruled out strategic considerations as the reason for these findings, and concluded that giving respondents time to think resulted in WTP bids of superior quality.

The expectation that time to think would lower WTP is refuted in another study led by Whittington (Whittington *et al*., 1993a) about improved sanitation systems in Ghana: Time to think did not seem to influence WTP, and even the presence of other people at the interview did not affect WTP.

In Whittington *et al*. (1997), the researchers ask the question whether time to think results in more pronounced scope effects. To answer this question, a split experimental design was developed that involves three plans of increasing scale ((a) sewer system only; (b) sewer system plus wastewater treatment plant; and (c) sewer system, wastewater treatment plant, plus regional plan to preserve surface water quality), and two time-to-think treatment (a standard questionnaire, plus one allowing two or three days to complete the interview), for a total of six combinations. The researchers found that people were able to appreciate the difference in size between programmes (a) and (b), whether or not they had been given time to think. Respondents who had been given time to think liked plan (c) less than plan (b), perhaps because reflecting upon the matter had made them realize (and reject) the role of the government in the provision of programme (c), or because they had a better chance to identify the opportunity for free riding behaviours.

The time-to-think protocol was also adopted by Swallow and Woudyalew (1994) in their tsetse fly control study.

K. Other Approaches

A somewhat different approach to valuing a safe drinking water is presented in Rosado (1998). Rather than querying respondents about their willingness to pay for safer water, this paper uses information about their actual behaviour to avoid drinking unsafe water in an urban agglomeration in the state of Espirito Santo, Brazil. Specifically, a number of options are identified, such as filtering the water or boiling it, each of which implies a certain cost and time requirement. A nested logit model is then fit to predict the option selected by the respondent as a function of the cost and time requirement for each alternative, interacted with respondent socio-demographic characteristics. The value of safer drinking water is then computed as the compensating variation of eliminating one of the possible water disinfection options (see Freeman, 1993, for the relevant formulae). Since this study focuses on individual defensive behaviour, it should provide a lower bound for WTP for safer water, which could be compared with WTP elicited from a contingent valuation study. This approach has the advantages of being based on actual behaviour, and of getting around the complex issue of having to query respondents about reductions in the *probability* of exposure to contaminated water, and in the *probability* of becoming ill, having ingested contaminated water.

One of the most recent developments in valuation work based on stated preferences is the use of so-called "choice experiments." Instead of presenting the respondent with a single scenario involving the provision of a good or public programme at a stated cost, a survey adopting the "choice experiment" format asks respondents to choose between pairs of programmes, programmes A and B, and involving different levels of the programmes' attributes and different costs. It can be shown (Louviere, 1996) that WTP can be identified as long as in addition to A and B the respondent is offered the option to "do nothing" (an option that involves not changing the status quo, and not paying anything at all). In general, respondents participating

in a "choice experiment" study are offered several pairs containing various combinations of policy or good attributes and costs (plus the "do nothing" option), so that one can obtain more information from any given respondent about the marginal valuation of each attribute.

Proponents of the "choice experiments" method believe that it has several advantages: Presumably, it encourages respondents to concentrate on the trade-offs between characteristics of the good or public programme, as opposed to taking a position for or against a policy. Adamowicz et al (1996) argue that the repeated nature of the choice task makes it difficult to behave strategically. Much like contingent valuation, choice experiments allow valuation of a good at conditions that do not currently exist. For instance, it would not be possible to use observed behaviours to place a value on cleaning up a lake if the lake has always been polluted. Possible difficulties associated with choice experiments include respondent fatigue, frustration (if the respondent dislikes all of the possible alternatives), and the decision to ignore one of the attributes if its level lacks credibility.

Although choice experiments have been used extensively in the United States and Canada in transportation studies (especially to explain mode choice as a function of its attributes), marketing studies, and natural resource damages assessment work, we are not aware of any applications in developing countries.

Jayne *et al*. (1996) present an application of another stated-preference method known as contingent behaviour. Contingent behaviour questions typically ask respondents what they would do under specified hypothetical circumstances. If the price per trip to destination X would rise to Y, would the respondent stop taking trips to X altogether? If the price of a commodity would rise (or drop) to X, how much of that commodity would the respondent purchase? Jayne et al ask respondents in Kenya, Zimbabwe and Mozambique what their expected purchases of refined cornmeal, coarse cornmeal and other substitutes would be under a variety of price and deregulation scenarios. The stated preference data collected in this fashion was combined with revealed preference data (the respondents' actual purchases of these commodities) to estimate demand functions that predicted well the actual purchases after price controls were lifted and other reforms were enacted.

In sum, we believe the applications of the method of contingent valuation in developing countries have generally followed high standards, and have produced useful results. They have also uncovered a number of difficulties associated with the description of the commodity, the role of the government in providing public programmes, and the presentation of the cost information to the respondent. We hope that this report will prove useful to those who wish to design and conduct new contingent contingent valuation surveys in developing countries, and will offer guidance on how to interpret the results and findings from existing contingent valuation studies. We also hope that this report will offer ideas on alternative stated preference approaches.

References

Adamowicz, W.L., P. Boxall, M. Williams and J. Louviere. 1996. *Stated preference approaches for measuring passive use values: choice experiments versus contingent valuation.* Working Paper.

Alberini, A. 1995. Optimal designs for discrete choice contingent valuation surveys: single-bound, double-bound and bivariate models. *Journal of Environmental Economics and Management*, 28: 187-306.

Alberini, A. 1995. Testing willingness-to-pay models of discrete choice contingent valuation data. *Land Economics,* 71: 83-95.

Alberini, A., K. Boyle and M. Welsh. 1999. *Analysis of contingent valuation data with multiple bids and response options allowing respondents to express uncertainty.* University of Colorado Discussion Paper 99-18, Boulder, CO, USA. October.

Alberini, A., M. Cropper, T.-T. Fu, A. Krupnick, J.-T. Liu, D. Shaw, and W. Harrington. 1997. Valuing health effects of air pollution in developing countries: the case of Taiwan," *Journal of Environmental Economics and Management*, 34: 107-126.

Alberini, A., B. Kanninen and R. T. Carson. 1997. Modeling response incentive effects in dichotomous choice contingent valuation data. *Land Economics,* 73(3): 309-324.

Alberini, A. and A. Krupnick. 1997. Air pollution and acute respiratory illness: evidence from Taiwan and Los Angeles. *American Journal of Agricultural Economics*, 79: 1620-1624.

Alberini, A. and A. Krupnick. 1998. Air quality and episodes of acute respiratory illness in Taiwan cities: evidence from survey data. *Journal of Urban Economics*, 44: 68-92.

Alberini, A. and A. Krupnick. 2000. Cost-of-illness and WTP estimates of the benefits of improved air quality: evidence from Taiwan. *Land Economics*, forthcoming.

Altaf, M.A., and J.A. Hughes. 1994. Measuring the demand for improved urban sanitation services: results of a contingent valuation study in Ouagadougou, Burkina Faso. *Urban Studies*, 31(4): 1763-1776.

Altaf, M.A., D. Whittington, H. Jamal, and V.K. Smith. 1993. Rethinking rural water supply policy in the Punjab, Pakistan. *Water Resources Research*, 29(7): 1943-1954.

Arrow, K., R. Solow, P.R. Portney, E.E. Leamer. R. Radner, and H. Schuman. 1993. Report of the NOAA Panel on Contingent Valuation. *Federal Register,* 58: 4601-4614.

Boyle, K., M.P. Welsh, and R.C. Bishop. 1988. Validation of empirical measures of welfare change: comments and extension. *Land Economics*, 64: 94-98.

Cameron, T.A. 1991. Interval estimates of non-market resource values from referendum contingent valuation surveys. *Land Economics* 67(4): 413-21.

Cameron, T.A. and D.D. Huppert. 1988. OLS versus ML estimation of non-market resource values with payment card interval data. *Journal of Environmental Economics and Management*, 17: 230-246.

Cameron, T.A., W.D. Shaw, and S. Ragland. 1996. Nonresponse bias in mail survey data: salience v. endogenous survey complexity. *In* J. A. Herriges and C.L. Kling (eds.), *Valuing the environment using recreation demand models*, London, UK: Edgar Elgar Publishing.

Carson, R.T. 1991. Constructed markets. *In* J. Braden and C. Kolstad (eds.), *Measuring the demand for environmental commodities*, Amsterdam: North-Holland.

Carson, R.T., N. Flores, K.M. Martin, and J.L. Wright. 1996. Contingent valuation and revealed preference methodologies: comparing the estimates for quasi-public goods. *Land Economics*, 72: 80-99.

Carson, R.T., W.M. Hanemann, R.J. Kopp, J.A. Krosnick, R.C. Mitchell, S. Presser, P.A. Ruud and V. Kerry Smith. 1998. Referendum design and contingent valuation: the NOAA Panel's no-vote recommendation. *Review of Economics and Statistics*, 80(3): 484-487.

Carson, R.T., R.C. Mitchell, M.W. Hanemann, R.J. Kopp, S. Presser and P.A. Ruud. 1994. *Contingent valuation and lost passive use: damages from the Exxon Valdez*. Resources for the Future Discussion paper QE94-18, Washington, D.C.

Chestnut, L.G., B. Ostro, N. Vichit-Vadakan, K.R. Smith and Feng C. Tsai. 1998. *Final Report. Health effects of particulate matter air pollution in Bangkok*. Paper prepared for the Air Quality and Noise Management, Pollution Control Department, Royal Thai Government, Bangkok, Thailand, under grant from the World Bank. Boulder, CO, USA: Stratus Consulting.

Choe, K., D. Whittington and D.T. Lauria. 1996. The economic benefits of surface water quality improvements in developing countries: A case study of Davao, Philippines. *Land Economics*, 72(4): 519-537.

Cooper, J. 1993. Optimal bid selection for dichotomous choice contingent valuation surveys. *Journal of Environmental Economics and Management*, 24: 25-40.

Cooper, J. 1994. A comparison of approaches to calculating confidence intervals for benefit measures from dichotomous choice contingent valuation surveys. *Land Economics*, 70(1):111-122.

Cooper, J. and M. Hanemann. 1994. *Referendum contingent valuation: how many bounds are enough?* Paper presented at 1994 Amer. Agr. Econ. Assoc. Convention in San Diego, CA, USA. Washington, D.C.: Economic Research Service, USDA.

Cooper, J. and T. Osborn. 1998. The effect of rental rates on the extension of conservation reserve program contracts. *American Journal of Agricultural Economics*, Vol. 80(February): 184-194.

Cooper, J., M. Hanemann and G. Signorello. 1999. One and one-half bound dichotomous choice contingent valuation. Manuscript, Economic Research Service, Washington, DC.

Creel, M. and J. Loomis. 1997. Semi-nonparametric distribution-free dichotomous choice contingent valuation. *Journal of Environmental Economics and Management* 32(March): 341-358.

Cropper, M. and A. Alberini. 1998. Contingent valuation. *In* P. Newman (ed.). *The New Palgrave Dictionary of Economics and the Law.* New York, USA: Stockton Press, and London: Macmillan Reference.

Dickie, M. and S. Gerking. 1991. Willingness to pay for ozone control: inferences from the demand for medical care. *Journal of Environmental Economics and Management*, 21: 1-16.

Ekstrand, E.R., and J.Loomis. 1998. Incorporating respondent uncertainty when estimating willingness to pay for protecting critical habitat for threatened and endangered fish. *Water Resources Research,* 34(11): 3149-3155.

Freeman, A. Myrick III. 1993. *The measurement of environmental and resource values: theory and methods*, Washington, D.C.: Resources for the Future.

Hadker, N., S. Sharma, A. David and T.R. Murateed Haran. 1997. Willingness to pay for Borivli National Park: evidence from a contingent valuation. *Ecological Economics*, 21: 105-122.

Hammitt, J. 2000. *Evaluating the effect of visual aids on willingness to pay for a reduction in mortality risk.* Paper presented at the annual ASSA meetings, Boston, MA, January 2000.

Hanemann, W.M. 1991. Willingness to pay and willingness to accept: how much can they differ? *American Economic Review*, 81(3): 635-647.

Hanemann, W.M., J. Loomis and B.J. Kanninen. 1991. Statistical efficiency of double-bounded dichotomous choice contingent valuation. *American Journal of Agricultural Economics* 73(4): 1255-1263.

Harrington, W. and P.R. Portney. 1987. Valuing the benefits of health and safety regulation. *Journal of Urban Economics*, 22: 101-112.

Hoehn, J.P. and A. Randall. 1987. A satisfactory benefit cost indicator from contingent valuation. *Journal of Environmental Economics and Management*, 14: 226-247.

Jayne, T.S., L.Rubey, F. Lupi, D. Tschirley, and M. Weber. 1996. Estimating consumer response to food market reform using stated preference data: evidence from Eastern and Southern Africa. *American Journal of Agricultural Economics*, 78: 820-824.

Kanninen, B.J. 1991. *Optimal experimental design for contingent valuation surveys*. Ph.D. dissertation, University of California Berkeley, USA.

Kanninen, B.J. 1995. Bias in discrete response contingent valuation. *Journal of Environmental Economics and Management*, 28(1): 114-125.

Krupnick, A. *et al.* 1996. The value of the health benefits from ambient air quality improvements in Central and Eastern Europe: an exercise in benefit transfer. *Environmental and Resource Economics*, 7(4): 307-322.

Loehman, E.T., S.V. Berg, A.A. Arroyo, R.A. Hedinger, J.M. Schwartz, M.E. Shaw, W. Fahien, V.H. De, R.P. Fishe, D.E. Rio, W.F. Rossley and A.E.S. Green. 1979. Distributional analysis of regional benefits and costs of air quality control. *Journal of Environmental Economics and Management*, 6: 222-243.

Loehman, E.T. and V.H. De. 1982. Application of stochastic choice modeling to policy analysis of public goods: a case study of air quality improvements. *Review of Economic and Statistics*, 64: 474-480.

Louviere, J.J. 1996. Combining revealed and stated preference data: the rescaling revolution. Paper presented at the AERE Workshop, Tahoe City, CA, June.

McPhail, A.A. 1994. Why don't households connect to the piped water system? Observations from Tunis, Tunisia. *Land Economics*, 70(2): 189-196.

Mitchell, R.C. and R.T. Carson. 1989. *Using surveys to value public goods: the contingent valuation method.* Washington, D.C.: Resources for the Future.

Navrud, S. and E.D. Mungatana. 1994. Environmental valuation in developing countries: the recreational value of wildlife viewing. *Ecological Economics*, 11: 135-151.

Ostro, B. 1994. *Estimating the health effects of air pollutants: a method with an application to Jakarta.* The World Bank, Policy Research Paper 1301, May.

Randall, A., B.C. Ives and C. Eastman. 1974. Bidding games for valuation of aesthetic and environmental improvements. *Journal of Environmental Economics and Management*, 1: 132-149.

Ready, R.C., J.C. Whitehead and G.C. Blomquist. 1995. Contingent valuation when respondents are ambivalent. *Journal of Environmental Economics and Management*, 29: 181-196.

Rosado, M. 1998. *Willingness to pay for drinking water in urban areas of developing countries.* Paper presented to the AAEA annual meetings, Salt Lake City, Utah, USA, August.

Rowe, R. D. and L. G. Chestnut. 1985. *Valuing changes in morbidity: WTP versus COI measures.* Energy and Resource Consultants, Inc., Boulder, CO, USA.

Rowe, R.D., W.D. Schultze and W.S. Breffle. 1996. A test for payment card aiases," *Journal of Environmental Economics and Management*, 31(2): 178-185.

Shultz, S., J. Pinazzo, and M. Cifuentes. 1998. Opportunities and limitations of contingent valuation surveys to determine national park entrance fees: evidence from Costa Rica. *Environment and Development Economics*, 3: 131-149.

Shyamsundar, P. and R. Kramer. 1996. Tropical forest protection: an empirical analysis of the costs borne by local people. *Journal of Environmental Economics and Management*, 31: 129-144.

Singh, B., R. Ramasubban, R. Bhatia, J. Briscoe, C. Griffin, and C. Kim. 1993. Rural water supply in Kerala, India: how to emerge from a low-level equilibrium trap. *Water Resources Research*, 29(7): 1931-1942.

Swallow, B.M. and M. Woudyalew. 1994. Evaluating willingness to contribute to a local public good: application of contingent valuation to tsetse control in Ethiopia. *Ecological Economics*, 11: 153-161.

The World Bank Water Demand Research Team. 1993. The demand for water in rural areas: determinants and policy implications. *The World Bank Research Observer*, 8(1): 47-70.

Tolley, G., L. Babcock, M. Berger, A. Bilotti, G. Blomquist, M. Brien, R. Fabian, G. Fishelson, C. Kahn, A. Kelly, D. Kenkel, R. Krumm, T. Miller, R. Oshfeldt, S. Rosen, W. Webb, W. Wilson and M. Zelder. 1986. *Valuation of reductions in human health symptoms and risks.* US EPA Report under Grant no. CR-811053-01-0, US EPA, Washington, DC.

Wang, Hua. 1997. Treatment of 'don't know' responses in contingent valuation survey: a random qaluation model. *Journal of Environmental Economics and Management*, 32: 219-232.

Welsh, M.P. and G.L. Poe. 1998. Elicitation effects in contingent valuation: comparisons to a multiple bounded discrete choice approach. *Journal of Environmental Economics and Management*, 36: 170-185.

Whittington, D. 1998. Administering contingent valuation surveys in developing countries. *World Development*, 26 (1): 21-30.

Whittington, D., D.T. Lauria, and X. Mu. 1991. A study of water vending and willingness to pay for water in Onitsha, Nigeria. *World Development*, 19(2/3): 179-198.

Whittington, D., Choe and D. Lauria. 1997. The effect of giving respondents 'time to think' on tests of scope: an experiment in Calamba, Philippines. *In* R. Kopp, W.W. Pommerehne and N. Schwartz (eds.), *Determining the value of non-marketed goods*. Kluwer.

Whittington, D., J. Briscoe, X. Mu and W. Barron. 1990a. Estimating the willingness to pay for water services in developing countries: a case study of the use of contingent valuation surveys in Southern Haiti. *Economic Development and Cultural Change*, 293-311.

Whittington, D., A. Okarafor, A. Okore, and A. McPhail. 1990b. Strategy for cost recovery in the rural district sector: a case study of Nsukka District, Anambra State, Nigeria. *Water Resources Research*, 26(9): 1899-1913

Whittington, D., V.K. Smith, A. Okorafor, A. Okore, L. Lium and A. McPhail. 1992. Giving respondents time to think in contingent valuation studies: a developing country application. *Journal of Environmental Economics and Management*, 22(3): 205-225.

Whittington, D., D.T. Lauria, K. Choe, J.A. Hughes and V. Swarna. 1993a. Household sanitation in Kumasi, Ghana: a description of current practices, attitudes, and perceptions. *World Development*, 21(5): 733-748.

Whittington, D., D.T. Lauria, A. Wright, L. Choe, J.A. Hughes and V. Swarna. 1993b. Household demand for improved sanitation services in Kumasi, Ghana: a contingent valuation study. *Water Resources Research*, 29(6): 1539-1560.

Whittington, D., J. Davis, H. Miarsono, and R. Pollard. 1995. *Urban sewer planning in developing countries and the 'neighborhood deal': a case study of Semarang, Indonesia*. UES Working papers, The World Bank, Washington, D.C.