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Article

Validity of contingent valuation estimates from developing countries: scope sensitivity analysis

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Abstract In developing countries contingent valuation (CV) has become an important tool for estimating willingness to pay (WTP). So far, however, the CV studies usually have not assessed the validity of the WTP estimates mainly due to ambiguities in the criteria for scope sensitivity analysis. In this article we clarify the criteria from theoretical and empirical aspects. The main debate on scope sensitivity analysis targets the proportionality theory: One group supports strong proportionality, and the other group supports weak proportionality. We highlight the shortcomings of strong proportionality and support weak proportionality. We set up the criteria for statistical significance and plausible responsiveness between the WTP and its explanatory variables. We conducted scope sensitivity of our case study from rural Pakistan to show its applicability in developing countries and to test the validity of our WTP estimates. Statistical analysis, based on the maintained hypothesis, reveals that the magnitude of the benefits and per capita income are significant variables that influence the WTP. The Kruskall-Wallis test reconfirmed the significance of the size of the benefits. Plausible responsiveness is evident from the influence of the household characteristics over the WTP. Finally, we concluded that CV can provide valid results in developing countries if the survey is conducted according to the mainstream guidelines. Further empirical testing is required to support the criterion of plausible responsiveness.

Key words Scope sensitivity analysis · Contingent valuation · Water supply · Health risks · Developing countries

1 Introduction

Willingness to pay (WTP) is a nonmarket valuation method for placing a value on environmental goods. The theoretical foundations for the WTP are based on the individual preference theory (Batemen and Turner 1993). We can estimate the individual welfare by making WTP equal to the Hicksian compensating variance, where the utility of income for individuals is assumed to be constant across income groups. We can aggregate individual welfare to estimate social welfare by adopting the Kaldor-Hicks criterion, which is an efficiency criterion based on the assumption that gainers can compensate the losers, as gains are higher than the losses (for detailed insights, see Boadway and Bruce 1984 and Johansson 1987).

There are various techniques to measure those individual preferences, including the travel cost method and the averting behavior method under revealed preference (RP) techniques and contingent valuation (CV) and conjoint analysis under stated preference (SP) techniques (Whitehead and Houtven 1997). Cost of illness (COI) has been a popular technique for assessing the WTP for improvements in environmental health. Of all those techniques, CV has prompted the most serious investigation of individual preferences ever undertaken in economics (Smith 2000).

Contingent valuation is gaining popularity with academicians and developmental agencies in developing countries (Whittington 1998). It is difficult to implement RP techniques and COI to estimate WTP in rural areas of developing countries owing to nonexistent alternative markets for observing behavior because of the difficulty of converting time into monetary values (as there is high rate of surplus and marginal labor), the nonavailability of epidemiological data, and the variation in mitigation costs for the same sickness episodes (Memon 2001; Memon and Matsuoka 2001). Hence CV is the most viable option for estimating WTP for environmental goods and services in those areas.

It is a direct method where many biases on the part of interviewer, the design and implementation of the survey, and the respondent can jeopardize the reliability and validity of the CV surveys (Mitchel and Carson 1989). The reliability of CV can be improved by reducing the biases (Batemen and Turner 1993). A prominent panel under the National Oceanic and Atmospheric Administration (NOAA) provides mainstream guidelines for obtaining reliable, valid results (Arrow et al. 1993). The validity of CV-based WTP is still the most critical issue in contemporary research (Carson et al. 2000).

The validity is mainly assessed from the answer to a question: How does the WTP vary with factors that could logically be expected to influence it under an economic theory? This is usually termed a *scope effect* or *scope sensitivity analysis*. Scope sensitivity is considered a necessary condition for the validity of the CV-based WTP (Hammitt 2000a). The scope test, to measure the sensitivity of the WTP in accordance with the change in benefits, has attracted most attention as it has been regarded as the acid test for a CV study (Smith 2000).

The previous research on scope sensitivity was mainly focused on the valuation of natural assets due to the valuation debate over the famous Exxon-Valdez oil spill. The most recent research is targeting environmental health risks; and scope sensitivity analysis of those CV studies has mainly failed to uphold the validity of the WTP (Hammitt 2000a), generally due to problems understanding the change in risk (Hammitt and Graham 1999). The respondents may not be familiar with the commodities and the units of change in risk, which are quite ambiguous (Krupnick et al. 1999). Furthermore, individuals may provide inaccurate information due to strategic behavior as a result of the constructed nature of the survey (Burtraw and Krupnick 1999).

Therefore, failure to stand by the scope test was attributed to the deficiencies of the design and implementation of the CV survey. However, even design and administration of CV survey in accordance with the best practice guidelines may still fail to get valid WTP, mainly because of ambiguities in the scope sensitivity analysis. The criteria for conducting the scope test is the most debatable issue in current research. On one hand, the strict measures require that the WTP be more than proportionality or at least near proportionality with the change in the risks (Diamond 1996; Hammitt 2000a). On the other hand, proponents of CV suggest that the WTP should change with the change in the risks, but it is difficult to predict the proportionality (Hanemann 1996; Carson et al. 2000; Smith 2000).

This article sums up the contemporary debate on the scope sensitivity analysis for the CV studies on environmental health risks. Thereafter, we propose plausible criteria for assessing the validity of CV-based WTP estimates. We conducted scope sensitivity analyses of our own CV survey in Pakistan to show its applicability in a developing country (Memon and Matsuoka 2001). The organization of this article is as follows: In Section 2, based on a review of the mainstream debate, we assess the shortcomings of strong proportionality and support weak proportionality. We also set up the criteria and discuss the statistical tools to test weak proportionality. In Section 3 we test the criteria for an empirical study. We first briefly discuss our CV survey with reference to design, implementation, and results of the study. Thereafter, we conduct the scope sensitivity analysis for this case study. In Section 4 we conclude this research by looking into the important outcomes and the future implications for developing countries.

2 Criteria for scope sensitivity analysis

The debate over the validity of CV to assess the value of damage to the natural assets led to the formulation of NOAA's guidelines for the best practice of CV. Among those guidelines, the second item, "burden of proof" requirements, is related to the scope sensitivity analysis of the stated WTP values. Hence, scope sensitivity is taken as a criterion for judging the validity of the CV estimates. Baron (1996) suggested that scope insensitivity is simply not permitted unless it is a consequence of a flat utility function. Most critics, including Diamond (1996) and Hausman (1993) also adapted this test and concluded that CV is not a valid, reliable tool.

Although most of the proponents and critics of CV technique agree on scope sensitivity as a basic condition for accepting WTP estimates as valid, the criteria for scope sensitivity are still debatable. One group insists on the proportionality criterion, where the WTP should increase in the same proportion as the increase in benefits (Diamond 1996; Hammitt 2000a). The other group is in favor of weak proportionality, where the WTP should increase with the benefits but not necessarily in the same proportion (Arrow et al. 1993; Hanemann 1996; Smith and Osborne 1996).

To support either strong proportionality or weak proportionality, we review the theoretical and empirical issues in this regard. We first look at earlier discussions on the proportionality theory and then review the contemporary discussions on environmental health risks. We then highlight the shortcomings of strong proportionality for environmental health risks and set up the criteria for conducting a scope sensitivity analysis.

2.1 Early discussions on proportionality theory: natural assets

Mitchel and Carson (1989) suggested that the scope effect is the necessary condition to assess the validity of the WTP estimates. Their work is a landmark in the literature on CV, and it mainly targets the CV-based WTP to preserve natural assets. However, they did not clearly indicate the criteria, either strong proportionality or weak proportionality, for scope sensitivity analysis. The debate on strong proportionality began with the valuation of damage to natural assets due to the famous Exxon-Valdez oil spill.

The critics of CV led by Diamond (1996) have proposed that the magnitude of change in the WTP should be more than twofold if the benefits are increased twofold. The proponents of CV led by Hanemann (1996) have rejected strong proportionality. Hanemann argued that the economic theory predicts only that the WTP should increase with income or with the scope of items being valued, but it is not compulsory to increase it more than proportionally. The NOAA supports weak proportionality, and Smith and Osborne (1996) clarified weak proportionality, stating that the WTP values should be significantly related and plausibly responsive to the change in benefits (Smith and Osborne 1996).

2.2 Latest discussions on proportionality theory: environmental health risks

In the most recent discussions, Hammitt tried to make the point that health risks appear differently in a utility function than those of preserving natural environmental assets (Corso et al. 2000; Hammitt 2000a). He argued that the necessary condition implies that change in the WTP should be nearly proportional to the change in the mortality risks. As per his calculations, the change in risk probabilities is extremely small in comparison to even baseline risks, and they can be assumed to be locally linear. However, even a small change, from 0.01% to 0.02% in the baseline risk at 28 per 10000, would change the WTP from about US$500 to about US$1000 for a person with an annual income of US$40000. Further small incremental changes in the risk should also increase the WTP accordingly.

It is difficult to assume that this change in income is locally linear, as it affects other consumption patterns. Thus, it is implausible that WTP would be linear and in near proportionality with the change in the risks, especially when the risks are assumed to be environmental health risks, which are considered involuntary (Kask and Shogren 1994). The WTP for volunteer risks (hedonic wages) and for accident risks (seat belts or air bags) target specific people in the society, so it may not be comparable to that for environmental health risks.

The effect of income on the scope has also been considered tiny (Hammitt and Graham 1999), although this effect is linked with the substitution effect (Hanemann 1994). The marginal rate of substitution to the value of an incremental change (air pollution) depends on how other sources of exposure enter the utility function (Smith 1993).

2.3 Shortcomings of the near proportionality theory

The theoretical assumptions of Hammitt's "near proportionality" targets the same individual or household, with other characteristics being constant, who are faced with a choice to buy either lower risk reduction or higher risk reduction at near proportional WTP. This may be treated as an internal test. Furthermore, the small change in health risks is treated as locally linear. The empirical assumption is based on the marginal utility of income, which is constantly lower for other goods than for that of health risk at various levels. Moreover, the respondent does not try to maximize the expected utility.

Both of those assumptions are weak. The change in the health risks affects the other characteristics, and simultaneously those characteristics shift the tradeoff or equilibrium point for WTP versus risk. The "health risk reduction" is a normal good; and the marginal utility of a normal good decreases with its increased quantity. Hence, along with other consumption requirements, it is difficult to assume that most people keep buying additional risk reduction at the same cost. Hanemann (1996) observed that one can always generate specific predictions by introducing some assumptions, but those predictions are no more valid than the assumptions on which they rest.

2.4 Support for the weak proportionality theory

The shortcomings of the strong proportionality theory makes it evident that weak proportionality criteria are plausible for conducting sensitivity analysis of CV-based WTP estimates. Furthermore, the support for weak proportionality lies in the theory of marginal diminishing returns, where each additional unit of benefit adds less utility than the previous unit, leading toward a convex utility curve (Hanemann 1996). This theory of diminishing returns has been empirically proved through various market studies, as the expenditures on all the normal goods have diminishing returns. Health is also considered normal goods in a household budget.

2.5 Internal versus external analysis

Hammitt and Graham (1999) suggested that the scope sensitivity effect could be "internal" and "external." The internal scope test measures the change in WTP for different levels of risk for the same respondent, whereas the external test measures the change in WTP for various respondents at different risk levels. The internal sensitivity analysis could be straightforward, as respondents can compare their previous responses with the change in the risks (Hammitt and Graham 1999).

For internal analysis, the same person is asked for a CV scenario with two or more levels of benefits. If he or she can have a different WTP for a different level of the benefits, we can determine if the WTP estimates can meet the strong proportionality or weak proportionality criteria. The flat WTP for all the levels of benefits indicates scope insensitivity, and it is difficult to accept those WTP estimates. For external analysis, we can compare the WTP estimates from different persons who were given a CV scenario with a different level of benefits.

It is also difficult to explain empirically about the different levels of the health risks from the same environmental source to the same respondent. The environmental media, such as availability of clean water, can reduce the health risks by a certain level (Cairncross 1996), and it is difficult to produce any practical example showing that the incremental quantity and quality of water can reduce the risk for the same individual or household with constant characteristics. Similarly, the problem of thresholds for air pollution-related concentration levels versus health risks (Pears and Crowards 1996) also make it difficult to draw various levels of health risk for the same respondent. Therefore, it is empirically feasible and meaningful to compare the WTP of two respondents in accordance with the changes in their health risks.

2.6 Criteria for adapting weak proportionality

If we redefine the value of statistical life (VSL) model by Corso et al. (2000) as the value of a healthy day (VHD), we can derive criteria for scope sensitivity analysis. Here we can assume that the respondent is experiencing healthy and sick days, where sickness is assumed to be water-related sickness. The utility of a healthy day is given as $U_h(y)$, and the utility of a sick day is given as $U_s(y)$. If p is the probability of getting sick on a healthy day, the respondent maximizes the expected state-dependent utility as:

$$EU(p,y) = (1-p)U_h(y) + pU_s(y) \tag{1}$$

where utility is a function of income y, conditional on being healthy or sick on that day. Differentiating this expression can yield the standard result:

$$VHD = \frac{dy}{dp} = \frac{U_h(y) - U_s(y)}{(1-p)U'_h(y) + pU'_s(y)} \tag{2}$$

We can assume that a healthy day is preferred to a sick day $[U_h(y) > U_s(y)]$, the marginal utility of income is not negative, and it is greater for being healthy than being sick $[U'_h(y) > U'_s(y) \geq 0]$. Therefore, the value of a healthy day increases with p and y. The income effect could be extremely small (Carson et al. 2000), and the marginal rate of substitution between health benefits and income is less than unity (Hanemann 1996). Finally, the marginal rate of substitution depends on how other factors affect the utility function (Smith 1993).

This reasoning helps support the basic criteria of statistical significance and the plausible responsiveness of the WTP values, as interpreted by Smith and Osborne (1996) from NOAA guidelines. Assessment of the statistical significance is quite straightforward and has been tested by various studies on scope sensitivity. However, plausible responsiveness has not yet been clearly identified. This clarification requires an understanding of the WTP model based on risk and population characteristics (Hammitt 2000b).

Each individual shows a different WTP depending on the risk and population characteristics. Hence, the changes in WTP values follow the economic considerations of those characteristics. First, the economic aspects of the risk characteristics should be considered. The short-term and long-term health effects may yield different economic costs. The mitigation costs may be different for different respondents with the same risk, depending on the socioeconomic aspects. The pain or other psychological considerations can also be different for different diseases having the same mitigation costs.

The different population characteristics may also have different economic implications, even with the same risk characteristics. The income level is important for deciding among the various mitigation activities with related costs as well as because of the different utility level of additional income for rich and poor people when they are healthy or sick. The proportion of literate people also makes a difference, as literacy increases hygienic practices and consequently affords a change in risk. Women are usually the primary stakeholders for projects reducing environmental health risks due to their role as the caretaker for sick family members. Furthermore, because of increased support for gender-oriented development, they are gaining voice and choice and so are having an impact on the household WTP.

The plausibility of the WTP should therefore be judged in accordance with the economic implications of the risk and the population characteristics, including the nature of the risk and its mitigation and psychological costs, income level, lost income while sick, level of literacy, and impact on the primary stakeholders. This implies that a change in the risks would yield different WTP for different individuals or households having different characteristics.

2.7 Statistical tools

The final step to implementing the scope test is a description of the statistical tools. We have adopted linear and semi-log ordinary least squares (OLS) models, as most of the studies follow these models. Manning and Mullahy (1999) observed that OLS with logged dependent variables seems to be resilient to various data problems, and it deals better with heavy-tailed distributions than any of generalized log models (GLMs). Moreover, semilog distribution for WTP keeps the interpretation of coefficients straightforward, and the fit is close to that of the Weibull distribution (Krupnick et al. 1999).

The statistical output is important for judging the theoretical validity of CV-based WTP. Here we judge whether the sign and size of the estimated coefficients are consistent with the theoretical expectations. Moreover, in the CV model only those variables should be included that are expected by the theory, precluding a data-mining approach to obtain the highest R^2. Low R^2 values are not necessarily evidence of theoretical inconsistency; they could merely be indicative of less tightly clustered observations around the regression line and the stochastic variation in the data that overshadows the systematic influence of variables (Garrod and Willis 1999, p. 152). Mitchel and Carson (1989, p. 213) suggested that the R^2 for CV models should be higher than 0.15. Hence, an extremely high value of R^2, as in engineering models, is highly unlikely here. This is mainly due to the effect of various exogenous variables, which have not been taken into account for the CV models.

Furthermore, the Box-Cox model can be adapted to support OLS models. This is being used to normalize the error distribution, stabilize the error variance, and straighten the relation of Y to the X's (Fox 1997). If the Box-Cox parameter λ, is significantly different from zero, the model may have less curvature than what is implied by the semilog form; and if it is significantly different from 1, the model is different from the linear form (Smith and Osborne 1996). A nonlinear model supports a weak proportionality relation between the WTP and the benefits. A zero value suggests a flat curve or scope insensitivity, which may lead one to conclude that the WTP estimates are invalid.

Finally, the Kruskall-Wallis test can also be applied to reconfirm the significance of the size of the risk for the WTP. This test was the main statistical tool used by Diamond et al. (1993) to reject the null hypothesis; they subsequently concluded that CV studies could not provide valid WTP, as they fail the scope test. The Kruskall-Wallis test has been adopted as an alternative to one-way analysis of variance (ANOVA) to check the null hypothesis for the benefits being insensitive to the WTP. If the null hypothesis is rejected, we can conclude that the benefits differ in magnitude, but we cannot say how they differ (Bowen and Starr 1982). Nevertheless, this test can establish if the WTP is significantly related to the size of the risk.

3 Empirical case study from a developing country

The management of environmental goods and services is a crucial issue in developing countries due to lack of public funds. The developmental agencies are trying to involve communities (the primary beneficiaries) to manage these services, including their water supply. An assessment of the socioeconomic capacity of the communities is vital in this regard. The economic capacity is mainly related to the contributions from the households, and the WTP study may help estimate the economic viability of these services. This has motivated policymakers and academia to estimate WTP for various services. The critics of CV-based WTP question the validity of the WTP estimates with special reference to the developing countries. Although there are various specific guidelines (Whittington 1998)

to impel a good CV survey, a scope sensitivity analysis is still necessary. Therefore, we can adopt the above criteria to check the scope effects of the CV-based WTP estimates. We conducted a scope sensitivity analysis of our CV survey to reveal the implementation process of the scope sensitivity analysis as well as to test the scope effects for our CV-based WTP estimates.

3.1 CV-based WTP for water-related health risks in rural Pakistan

We conducted a CV survey to establish a relation between WTP and the rural water supply for Sindh Rural Water Supply and Sanitation Project (Fig. 1). Water-related health risks are the major economic benefits of a rural water supply. The WTP for the health-related outcomes depend on the risk and population characteristics (Hammitt 2000b). Household characteristics can be adopted as population characteristics to measure household WTP for health risks (Smith and Desvousges 1987). Moreover, focusing on a household, rather than an individual, helps reduce the effects of altruism (USEPA 2000).

We conducted a CV survey, in line with the mainstream guidelines for the best CV practice (Table 1), to assess the relation between the WTP and the health benefits of a rural water supply in Pakistan. Under a World Bank-assisted Sindh rural water supply project, community participation and women's organizations are the major requirements for a community water supply. This gives communities, particularly women, a better voice and choice.

For better risk communications and to reduce the strategic bias, we conducted the overall survey in accordance with the participatory rural appraisal (PRA)

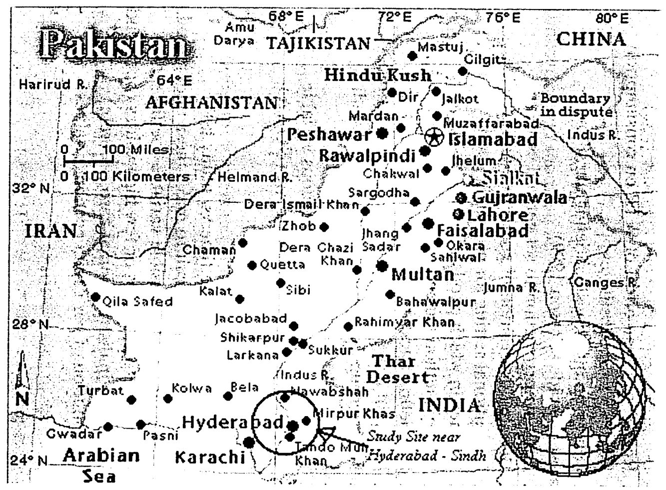

Fig. 1. Study site in Sindh Province of Pakistan

Table 1. Adoptability of various guidelines to implement the contingent valuation survey

Guidelines	Procedures adopted for implementing CVM in the case study of rural Sindh (Pakistan)
NOAA guidelines (quoted in Griffin et al. 1995)	
1. Interview in person rather than on the telephone	In-person and detailed interviews
2. Future rather than historical event	Change in water fee in the future
3. Referendum format (in contrast to open-ended)	Bidding game
4. Start with describing accurate scenario	Introductory statement and also detailed semistructured interview before starting CV survey
5. Reminder for an effect of WTP on consumption	Yes, reminding of impact on their spending pattern
6. Reminder for substitutes	Discussing alternatives for avoiding/curing diseases
7. Follow-up questions/debriefing questions	Informal discussion at the end of interview
CV: a user's guide (Carson 1999)	
1. Introductory section to set general context	Yes (same as NOAA)
2. Detailed description of goods to be offered	Yes, water quality and quantity will be improved
3. Institutional setting for providing goods	Yes, through village development association
4. Manner in which goods will be paid for	House connections
5. Survey method (open-ended is less in priority)	Bidding game (same as NOAA)
6. Debriefing questions to know the reliability	Yes (same as NOAA)
7. Relevant characteristics (demographic, attitudes)	Yes, household characteristics and water use pattern
8. Focus groups: outputs, language, pilot studies	Water supply Sindhi and Urdu: one pilot study
9. Population sample for public good	Proportionate sample to cover whole community
10. Data: bigger sample for continuous variable	About 30%–40% of whole community was covered
11. Mode of survey: in-person survey (NOAA)	In-person (same as NOAA)
12. Nonrespondents: treatment	Not applicable
13. Professional interviewers	A team of professionals conducted survey (sociologist, economist, doctor, engineer)
14. Payment vehicles: one time vs. utility bills	Continuous payment through water fee
15. WTA questions: difficult to make these understood	WTP questionnaire only
16. WTP (function): plausible variable coefficients	Most of results are plausible
17. Outliers: protest zeros or few high values (open-ended) and spike in distribution at zero (discrete)	No protest zeros and high values in comparison to income/affordability
18. Distribution of per capita economic values	
Guidelines for WTP studies (WASH 1988)	
1. Household characteristics	Yes (same as Carson 1999)
2. Avoiding biases	Precautions for strategic, information, and sampling biases
3. Bidding game: turning from upward to downward slope then take mid-point ($1.0 Y and $1.5 N; then WTP is $1.25)	
4. Team building to cover major aspects	Yes (same as Carson 1999)
CV surveys in developing countries (Whittington 1998)	
1. Explaining what a contingent study is all about	Prior to formal CV questionnaire, during participatory survey, respondents understood the nature, process, and type of answers required from them
2. Interpreting responses to contingent valuation questions	Debriefing session (same as NOAA guidelines and Carson 1999)
3. Setting referendum prices (90%–95% rejection for highest price)	Though our study is based on iterative bidding, the highest bid was proposed by hardly 10% of respondents. The range between minimum and maximum bid was also quite wide
4. Constructing joint public-private CV scenarios	Village development associations (VDAs) are prime stakeholders, and they operate and maintain the water supply system. This aspect is also covered in the participatory survey
5. Ethical problems in conducting contingent valuation surveys	
(a) When is the use of a referendum elicitation procedure unethical?	There was no split-type survey in the same community and respondents' confidence building was done during participatory survey
(b) How honest should one be about the institutional regimem contemplated for delivering the "hypothetical" goods or services	As mentioned, VDA is the main actor for delivering the goods. After sustainable delivery of the goods and democratic setup of the VDA, the respondents had confidence that the WTP values are only required to know whether delivery of the goods can be sustained over time within the same setup
Scope sensitivity test (Smith and Osborne 1996)	
1. Statistically significant	Yes
2. Plausibly responsive	Yes

WTP, willingness to pay; CV, contingent valuation; CVM, contingent valuation method; WTA, willingness to accept

(Chambers 1994a). The PRA is different from the traditional in-person interview, where interviewers arrive with a set of prepared questionnaires and conduct detailed structured interviews. Because of socioeconomic differences and other biases between the respondent and the interviewer, often the data from this interview is either not reliable or not sufficient. Furthermore, the interviewer records his or her own observations, which may be different from how local people see their own problems. Hence, the main principle of the PRA is based on the "from etic to emic" approach (Chambers 1994b). This suggests that we should change the pattern of data collection and move from the interviewer's description (etic) to the person's description (emic) (for detailed discussions on PRA, see Chambers 1994a,b).

The first two parts of our survey are based on semistructured interviews to gather the data about the family structure, household income, literacy, ex-ante and ex-post (RWS) water-related health impacts for all the household members, and health costs, including lost income due to sickness or due to taking care of sick persons. A checklist (Appendix 1) was used to gather the required information and direct data about the person's perception regarding changes in water-related sickness (diarrhea, malaria, skin diseases) episodes during the preceding year compared to the year before the water supply scheme was operational. This is the best option for collecting data on health risks where epidemiological records are often not available. Furthermore, the consumers can judge the health risks on their own to make rational decisions about mitigation activities (Ravenswaay and Wohl 1995).

Finally, when the household leaders and the interviewers were both clear about the change in health risks due to the water supply and about household budget constraints, a formal CV survey was conducted (Appendix 2). They were asked if the water fee must be raised by the village development association (VDA) were they willing to contribute accordingly. Although single- and double-bounded dichotomous choice models are becoming more common for eliciting WTP, we adapted an iterative bidding game for various reasons. First, in a dichotomous choice model, we must use different bids (WTP amount) for different respondents to avoid starting point bias. However, our experience from a pilot survey suggested that in rural communities people talk to each other after the interview, and if they find out that different people got different WTP amounts, they become suspicious and lose confidence. To avoid starting point bias, we start with the existing water fee, which varies across villages based on the location or type of the water source (Fig. 2). Second, it is easy for the villagers to understand then addition or subtraction of small amounts from their household budget, as their income is low and their expenditures straightforward (a few basic commodities). Hence with the iterative bidding game, they feel comfortable about thinking it over and then accepting or rejecting the bid confidently. Third, we can calculate a WTP function from the iterative bidding game (Memon and Matsuoka 2001) in accordance with an economic theory. In this CV study, we analyzed the relation between WTP and household characteristics in accordance with the economic theory.

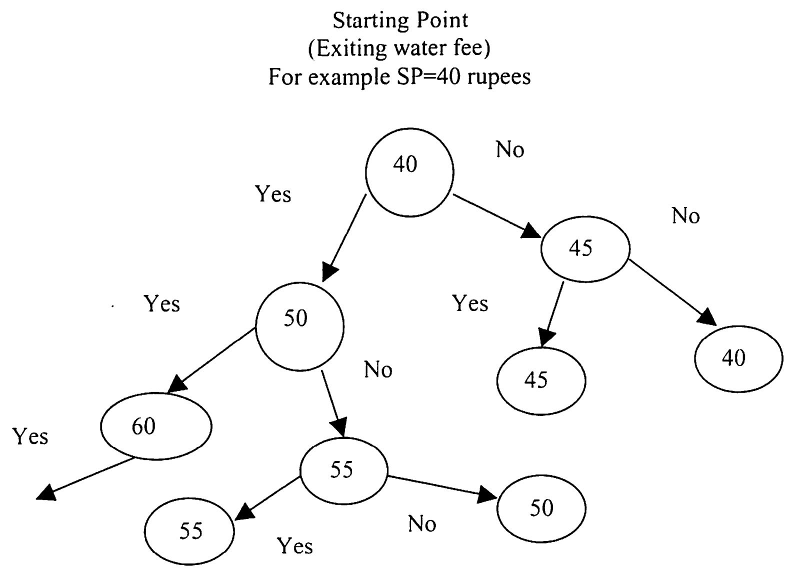

Fig. 2. Iterative bidding game to elicit willingness to pay (rupees)

The data were collected during July–August 2000 from five villages (Vidh, Khair Mohammad Jarwar, Vidh, Bhutto, Abdullah Khaskhelli) located in two districts (Hyderabad and Dadu) of Sindh Province in Pakistan. The total number of households in each village ranged from 70 to 100. Hence, we interviewed 30 households in each village, covering about 30%–45% of the population, which provides a representative data set. The selection was based on the proportional distribution of house conditions (poor, fair, good). The response rate was almost 100%, mainly due to using the participatory approach.

The results of this CV survey are shown in Table 2, which shows mean and median values of all the variables along with their behavior in the previous studies. From the statistical analysis (Table 3) it is evident that proportion of children, women, and literate family members are the most significant and positive variables in the full and reduced models for linear and semilog distributions. Income per capita is also a highly significant variable in the full model. As expected, the brackish water zone is significant and large in magnitude, although its impact is either 1 or 0. Family size is positive in the full model only. Lost income was not a significant factor mainly owing to marginal labor in the rural areas.

The above results did not tell us whether the WTP values fulfill the requirements of the economic theory. To check that validity, we conducted scope sensitivity analysis.

Table 2. Description of selected variables used in the analysis

Variable	Mean	Median	Description	Sign in previous studies	Ref.
WTP	41.07	40	Household willingness to pay for drinking water per month in rupees (50 rupees = 1 US$)		
Change in the risk	7.3	7.0	Number of reduced sickness episodes	+	(Crutchfield et al. 1997)
Income per capita	450	460	Total household income divided by number of household members	+	(Altaf et al. 1997)
Family size	8.6	8.0	Number of household members	+	(Altaf et al. 1997)
Children	44.52	44.44	Percent of children below 16 years of age in a household	–	(Altaf et al. 1997)
Women	21.78	22.22	Percent of women 16–60 years of age in a household	–	(Altaf et al. 1993)
Elders	6.14	0.00	Percentage of elders <60 years of age in a household	–	(Choe et al. 1996)
Literacy	45.56	45.45	Percent of literate persons in a household	+	(Lauria et al. 1999)
				–	(Choe et al. 1996)
Brackish	0.61	1.00	If the household is located in brackish water zone	+	(Altaf et al. 1993)

Positive and negative signs show the impact of household characteristics on WTP based on previous studies

Table 3. Relation between WTP and household characteristics

Dependent variable	Linear (full model)		Linear (reduced model)		Semi-log (full model)		Semi-log (reduced model)	
	Un-std.	Standardized	Un-std.	Standardized	Un-std.	Standardized	Un-std.	Standardized
Constant	−19.566	—	25.345***	—	1.686***	—	3.214	—
	(−1.269)		(5.928)		(4.603)		(28.337)	
Log (family size)	2.234***	0.434	−4.058E-02	−0.008	7.257E-02***	0.529	7.253E-03	0.053
	(5.783)		(−0.097)		(7.912)		(0.654)	
Children	9.874E-02**	0.148	0.100*	0.151	2.630E-03***	0.163	2.629E-03*	0.148
	(2.135)		(1.896)		(2.630)		(1.874)	
Women	0.143*	0.127	0.207**	0.185	4.717E-03**	0.157	6.109E-03**	0.204
	(1.840)		(2.319)		(2.554)		(2.574)	
Elders	−3.334E-02	−0.022	—	—	2.023E-05	0.005	—	—
	(−0.361)				(0.092)			
Literacy	0.108**	0.153	0.151***	0.214	2.323E-03**	0.123	3.792E-03**	0.202
	(2.346)		(2.660)		(2.130)		(2.519)	
Log (income/ capita)	4.655*	0.165	—	—	0.169***	0.223	—	—
	(2.017)				(3.076)			
Brackish	20.502***	0.771	—	—	0.842***	0.842	—	—
	(10.529)				(12.918)			
Samples	150	150	150	150	150	150	150	150
R^2	0.508	—	0.097	—	0.610	—	0.107	—
Adjusted R^2	0.484	—	0.072	—	0.591	—	0.082	—

The *t* values are given in parentheses
*** Correlation is significant at 1%
** Correlation is significant at 5%
* Correlation is significant at 10%

3.2 Scope sensitivity analysis: process and results

A maintained hypothesis, above the original hypothesis of the study, is required to implement the scope test (Smith and Osborne 1996). This hypothesis covers both aspects of the criteria: statistical significance and plausible responsiveness. First, we analyzed the impact of the change in the risks and income on the WTP. Here, in accordance with the criteria, we believe that both of those variables should be significant. However, the impact of the income would be tiny compared to the impact of the change in the health risks.

For the statistical analysis, our base model suggests that the WTP depends on the change in risk (β_1) and on household income (β_2). If α is constant, the general regression model can be written as:

$$WTP = \alpha + \beta_1 x_1 + \beta_2 x_2 \tag{3}$$

Both of the explanatory variables are plausible in accordance with the economic theory. Health benefits, in terms of reduced sickness episodes, save mitigation costs, time, and psychological pain. Therefore, people would be willing to pay for those health benefits. The second variable, income, normally has a positive relation with WTP, although its effect on WTP is minimal (Hammitt and Graham 1999). Rich people are willing to pay more for sickness than are poor people, as is evident from their higher mitigation costs. Hence a positive relation between income and WTP is economically plausible.

The second part of the hypothesis is based on the plausible responsiveness of WTP. We have already noted that the WTP model is based on risk and population characteristics. A similar change in health risks would yield a different WTP for households having different characteristics. To test this hypothesis, we divided our sample into two groups by earmarking the important characteristics with the minimum required content to have an influence over WTP. We believe that (1) per capita income of at least 600 rupees, (2) a proportion of women in the family of at least 33%, and (3) a proportion of literate household members of at least 33% are required to make an impact on WTP if the change in risks is uniform for both of the subgroups.

To test the "plausible responsiveness" between the WTP values and the change in the risk (reduced water-related sickness episodes), we divided our total sample into two subgroups based on the difference in per capita income (β_2), the proportion of women (β_3), and the proportion of literate household members (β_4), as mentioned in the hypothesis. These three variables (per capita income, proportion of women, proportion of literate members) have been used as dummy variables. For the upper level group the value is taken as 1, otherwise it is zero. The general regression model can be written as:

$$WTP = \alpha + \beta_1 x_1 + \beta_2 x_2 + \beta_3 x_3 + \beta_4 x_4 \tag{4}$$

We have already noted that the relation between WTP and health benefits and income is defined by economic theory and empirical findings. The third explanatory variable in the above equation is the proportion of women in a household, as they have the primary responsibility for collecting water and taking care of sick family members. Hence, their time, which otherwise might be used for household chores or economic activities, is being spent on taking care of sick family members. Hence it is logical to assume a positive relation for this variable. The fourth variable is the proportion of literate household members. Literate people feel more severe effects of the same sickness episodes; hence they usually spent more money on mitigation costs, as they visit doctors, unlike the illiterate people, who try local mitigation. Therefore, it is logical to note a positive relation between WTP for environmental health risks and literate people.

Table 4. Relations between WTP, health benefits, and income

	Linear		Semi-log		
Model	Unstandardized	Standardized	Unstandardized	Standardized	Box-Cox
Constant	22.433*** (6.971)	—	3.152*** (36.725)		4.264*** (56.624)
Change in the risk	2.116*** (7.029)	0.507	5.618E-02*** (6.997)	0.505	5.356E-02*** (6.561)
Income per capita	6.424E-03* (1.728)	0.125	1.984E-04** (2.001)	0.144	1.279E-05 (0.127)
No. of samples	150	150	1150	150	150
R^2	0.253	—	0.253	—	0.233
Adjusted R^2	0.243	—	0.243	—	0.223
Kruskall-Wallis test (chi-square = 38.454; P = 0.001)					λ = 0.22

The *t* values are given in parentheses
*** Correlation is significant at 1%
** Correlation is significant at 5%
* Correlation is significant at 10%

We adapted linear, semilog, and Box-Cox models, which show the statistically significant relation for the WTP in accordance with the change in the risks and per capita income (Table 4). Here, the change in the risks and per capita income yields positive coefficients in all models including the Box-Cox model. The coefficients in the Box-Cox model are not comparable with the coefficients of other models. However, we can compare the direction and sign of the coefficients to check their consistency. The magnitude of the standardized coefficients of linear and semilog models suggests that the health risks contribute more than 50% to WTP values, whereas the contribution of per capita income is small (12%–14%).

The Box-Cox parameter λ is calculated to be 0.22, which is quite different from 0 or 1. This follows a path similar to that observed by Smith and Osborne (1996). Hence, the curve for this model lies between the linear and semilog curves. The statistical significance of the relation between the change in risk and the WTP is evident, as the coefficients are significant at a level of 1%, showing the consistency in the scope sensitivity with all models. To further support this evidence the Kruskall-Wallis test shows that the null hypothesis, for benefits of the same magnitude, is rejected at P = 0.001.

Table 5. Scope sensitivity analysis for health benefits and the WTP

	Linear		Semi-log	
Model	Unstandardized	Standardized	Unstandardized	Standardized
Constant	22.319*** (9.217)	-	3.157*** (48.767)	
Change in risk	2.044*** (7.223)	0.490	5.410E-02*** (7.153)	0.485
Income per capita	4.348** (2.203)	0.159	0.130** (2.473)	0.178
Women	5.642** (2.586)	0.181	0.171*** (2.934)	0.206
Literacy	6.252*** (2.694)	0.189	0.151** (2.440)	0.171
No. of samples	150	150	150	150
R^2	0.335	—	0.336	—
Adjusted R^2	0.317	—	0.317	—

The *t* values are given in parentheses
*** Correlation is significant at 1%
** Correlation is significant at 5%
* Correlation is significant at 10%

When we divided the whole sample in two subgroups, the impact of the important household characteristics is evident (Table 5). The WTP is significantly sensitive to changes in household characteristics and changes in health risks. The distance between the slopes of the two subgroups is significantly different. Furthermore, households from the higher income group pay about 16% more than households from the lower income group. Similarly, households with adequate representation of women and literate members also contribute as much as 18% and 19%, respectively. Therefore, the variation in WTP is responsive to the variation in risks and household characteristics.

4 Conclusions

This research prompted us to arrive at two conclusions. First, CV can elicit valid WTP in developing countries. The most essential factor in the design and implementation of a CV survey for health risks is risk communication. The PRA approach is essential for optimally communicating the risk to the respondent. This approach also helps build the respondent's confidence and reduces strategic bias. Hence, the CV can produce appropriate results for the WTP.

Moreover, the validity of the WTP can be evaluated through scope sensitivity analysis. The scope or the change in the level of health benefits is statistically significant for the WTP. The behavior of the benefits and the WTP is influenced by household characteristics. Identifying those characteristics can help analyze the plausible responsiveness of the WTP to the change in environmental health risks, in accordance with the influence of those household characteristics. We can appreciate that a rural community in a developing country usually has fewer but stronger household characteristics, including income, literacy, and family structure.

Second, further research is required to test the CV-based WTP for the scope effect, particularly for plausible responsiveness analysis, based on a larger sample to confirm the behavior of household characteristics. It leads to a common consensus to check the validity of CV estimates. Moreover, it leads us to test the various CV instruments to improve risk communication, which plays a vital role in eliciting valid responses. Accordingly, appropriate modifications in the existing CV design can be proposed so even respondents in rural communities of developing countries can understand and appreciate the nature of a good or a change in environmental health risks. They then can provide appropriate responses in accordance with their budget constraints. Future research may further explore the behavior of household characteristics that affect WTP decision-making in different environments or at different locations and help formulate a benefit transfer function.

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Appendix 1. Field research on health benefits and WTP for rural water supply in Sindh (Pakistan)

Name of Village: **Date:**
Name of Household Leader:

1. Family size

Children	Men	Women	Elders

Adult age is assumed to be 16–60; elders are assumed to be 60+ years old

2. Literacy

Household leader	Others (number)

3. Household income

Constant monthly income (salary, etc.)	Varying income (live stock, agriculture, etc.)	Permanent earning (rental land, house, etc.)	Other	Total

4. Household assets

Housing		Appliances			Ownership			
Ownership	Construction	TV	Radio	Others	Shop	Cattle	Land	Other

Construction quality is taken as good, fair, or poor

5. Household time allocation (average for each male, female, child)

Daily activities	Agriculture	Business	Indoor income	Helping outdoors	House and child care	Schooling	Free time	Others
Each male								
Each female								
Each child								

6. Water consumption patterns

Washing clothes		Bathing		Cleaning with water: frequencies (high, medium, low)			
Place	Per week	Place	Per week	Hands	Face	Dishes	House

Place would be either inside house or at the water source like canal or well

7. Water-related diseases

Disease	Average attacks on children/month for whole year	No. of days a child is sick with each attack	Average attacks on adults/month for whole year	No. of days an adult is sick with each attack	Child mortality (per year)	Adult mortality (per year)
Diarrhea						
Malaria						
Skin disease						

8. Cost of illness for water-related diseases

	Child per each attack				Adult per each attack			
	Health unit or hakeem			Avg. loss of income to adults for taking care of sick child	Health unit or hakeem			Avg. loss of income while sick
Disease	No. of visits	Transport	Medical		No. of visits	Transport	Medical	
Diarrhea								
Malaria								
Skin disease								

Loss of income in real terms when no marginal or support household labor is available for substitution

Appendix 2. Questionnaire to ascertain household WTP

1. What amount are you paying as a monthly water fee to your village development association (VDA)?
2. As you mentioned about the difference in sickness, are health expenditures reduced? If yes, how do you utilize those savings (excluding water fees)?
   a. Food
   b. Education of children
   c. Utilities
   d. Investing in land, shop, cattle, business, or other investment
   e. Savings
   f. Other

3. Are you aware of the management of water supply by the village development association (VDA) and its running costs?
4. If your VDA has to increase the water fee because of increased running costs to keep the water supply working at the present level, you will again have to take some money out of funds you are now using for other purposes (see question 2a–f). Do you understand this?
5. If you were asked to increase your water fee by an additional 10 rupees, would you be willing to pay it?
   (If "yes," increase by another 10 rupees and continue the process until household leader says "no." If "no," go to question 6.)
6. Reduce the additional fee by 5 rupees and ask about WTP the additional water fee.
   (If "yes," write down the additional WTP. If "no," write down the additional WTP, if any.)