

About the Paper

Herath Gunatilake, Jui-Chen Yang, Subhrendu Pattanayak, and Caroline van den Berg demonstrate the use of contingent valuation survey findings to (i) make informed decisions on design of water supply and sanitation projects, and (ii) estimate benefits for project economic analysis. They demonstrate how to conduct validity tests for willingness-to-pay (WTP) estimates; segregate WTP for poor and nonpoor groups; conduct affordability analysis and target poor for special service delivery; and use conjoint analysis to unbundle demand. They further show how the findings of the study are used to assess the overall viability of water supply and sanitation projects.

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Willingness-to-Pay and Design of Water Supply and Sanitation Projects: A Case Study

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**WILLINGNESS-TO-PAY
AND DESIGN OF WATER SUPPLY
AND SANITATION PROJECTS:
A CASE STUDY**

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DECEMBER 2006

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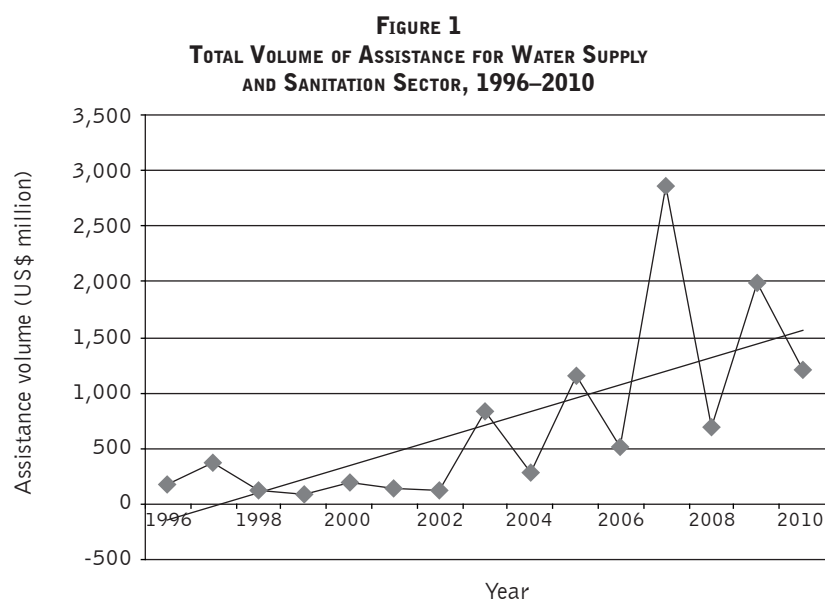
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ABSTRACT

Assistance of the Asian Development Bank in the water supply and sanitation (WSS) sector is predicted to increase. Improving demand assessments in project preparation is an identified need to enhance quality-at-entry. Using a case study, this paper demonstrates the usefulness of willingness-to-pay (WTP) studies in designing WSS projects. The case study was conducted to facilitate the design of public-private partnership for WSS in two service areas in Sri Lanka. The paper shows how to test the validity of WTP estimates and to use WTP data in generating useful supplementary information. It then illustrates the use of conjoint analysis to further understand demand. Finally, the paper shows how the findings can be used to assess the overall viability of the WSS project.

I. INTRODUCTION

Asia and the Pacific region accounts for about 57% (635 million) of the global population without safe drinking water and 72% (1.88 billion) of the global population without proper sanitation (UNDP 2006). Even among the urban households with access to water supply and sanitation (WSS), many receive low-quality services. The global agenda for poverty reduction—stated in the Millennium Development Goals (MDGs)—aims to halve the number of people without proper water supply and sanitation by 2015 (United Nations 2005, ADB 2005). The Asian Development Bank (ADB) has been providing assistance to the WSS sector in the region, aligning its strategy with this global agenda. From 1996 to 2006, ADB’s assistance to the WSS sector reached about \$3.98 billion, with an annual average of \$362 million (Figure 1).¹ ADB’s Medium-Term Strategy II 2006–2008 (ADB 2006b) identifies WSS as a priority sector, and its water financing program (ADB 2006a) plans to double water sector investments during 2006–2010.



Source: Data compiled by staff from ADB’s Project Processing Information System.

¹ Total assistance includes loans, grants, and technical assistance excluding project preparatory technical assistance (PPTA). The figures include integrated urban infrastructure projects with WSS components. Figures for 2007–2010 are tentative as they only indicate the potential future assistance based on projects included in the country strategy programs (CSPs).

Successive *Economic Analysis Retrospective* studies by the Economics and Research Department (ADB 2003a, 2004, and 2006c) found that there is room for improving demand assessments in ADB project preparation. In the case of WSS projects, willingness-to-pay (WTP) surveys—also known as contingent valuation² (CV) studies—are often used to assess demand and estimate project benefits. Of the 35 WSS projects processed by ADB during 2000–2006, 28 (80%) have used WTP surveys to estimate project benefits. A preliminary review shows that these surveys are not comprehensive enough to meet the required standards. The CV methodology has evolved to include econometric analysis to ensure the validity of WTP estimates. However, only two WTP surveys³ (11%) have made use of appropriate econometric methods. Moreover, WTP surveys conducted in preparing ADB WSS projects have focused mainly on estimating project benefits. However, as will be shown in this paper, apart from estimating project benefits, CV studies can generate supplementary information that that can be useful in designing WSS projects.

This paper draws from a CV study undertaken in 2003, which was intended to facilitate the design of a public–private partnership (PPP) to provide WSS services in southwest Sri Lanka. Using this case study, this paper aims to illustrate how the findings of a CV study can be used in designing WSS projects, besides estimating project benefits. First, the paper demonstrates the use of econometric methods to assess the validity of estimated WTP. Second, it illustrates how the estimated WTP function can be used to generate useful supplementary information⁴ to enhance project design. Third, the paper introduces conjoint analysis, a variant of CV, to illustrate its usefulness in further understanding demand. Fourth, the paper illustrates the use of the findings of the CV study, together with secondary information, to examine the overall viability of the PPP. While the paper demonstrates the value of supplementary information generated through a well-designed and carefully implemented CV study, it does not provide a complete set of practical guidelines⁵ on how to design and conduct CV studies.

² The terms CV and WTP studies are used interchangeably in this paper.

³ See ADB (2003b) and ADB (1992). This review was able to access only 18 reports of WTP studies.

⁴ This study examines (i) preference for different institutional arrangements (public or private) to provide WSS services; (ii) affordability of the poor for improved services with connection charges; (iii) uptake rates of improved services by different groups; and (iv) feasibility of spatially based pro-poor WSS service delivery options using the data collected in the WTP study.

⁵ Practical guidelines as to how state-of-the-art CV studies should be designed and conducted will be discussed in a forthcoming ERD technical note.

II. CONTINGENT VALUATION

A. General Design Issues

The CV method directly questions individuals as to how much they are willing to pay for a change in quantity or quality (or both) of a particular commodity. Economists generally prefer to use observed or revealed behavior in markets in estimating project benefits rather than directly questioning respondents. This is because direct questioning may result in many errors (Gunatilake 2003, Boardman et al. 1996, Hausman and Diamond 1994, Hanemann 1994). When direct revealed preference information (information on market demand) or indirect revealed preference information (information on surrogate markets) are not available, project economists are left with two choices: either confine to cost effectiveness analysis or estimate benefits using the CV method. Water supply and sanitation services are not generally traded in the markets, therefore, no information on market demand or competitive market prices is available to value benefits. Information on markets for bottled drinking water and other forms of traded water is sometimes available. However, such markets in developing countries are available only to a limited segment of the society. Moreover, bottled water or other forms of traded water do not represent all its domestic uses such as cooking, cleaning, and bathing. In situations where a considerable amount of time is spent in collecting water, time savings can be used to approximate the benefits of water supply projects. However, this is applicable only to certain situations. Benefits from sanitation projects may be reflected in land values of the project area. But the prevalence of distorted land markets in many Asian countries, and the lack of other reliable, required data to value land, prevent the use of the surrogate market method.⁶ In many cases, WSS projects constitute improvements of the existing systems for which information on market demand is often not available. Thus, the use of the CV method is inevitable in the economic analysis of WSS projects.

One should be cognizant of the limitations of directly questioning consumer preferences and must exercise caution in conducting CV studies. Over the last three decades, economists have debated about the appropriateness of using CV study findings for policy purposes. Critics generally question the accuracy of these studies. The CV methodology has improved over the last two decades, partly in response to expressed skepticism by some economists (Smith 2000). Particularly noteworthy among these improvements are the advances in economic theory and econometric methods associated with the CV method. The consensus today is that the CV method provides a useful tool for practical decision making, particularly when it is applied to value familiar use goods (Boardman et al. 1996). Use of CV method to value nonuse goods⁷ nevertheless remains contentious.

A CV analyst has to resolve a number of issues in using the CV method. The first is the selection of the type of survey methods to be used in the CV study. The literature unequivocally supports face-to-face interviews compared to other methods such as telephone interviews and postal surveys. Second, the analyst has to decide on the type of CV question. Basically, there are two types of CV questions: willingness-to-pay and willingness-to-accept-compensation (WAC). The appropriateness of these two largely depends on the property right of the commodity in question. In general, the literature supports the use of WTP questions. In the case of WSS, the property

⁶ See Gunatilake (2003) for a description of surrogate market method (hedonic pricing method).

⁷ Example of nonuse goods include habitats, endangered species, etc. The value of leaving such goods for future generations (bequest value) and the value of the knowledge of existence (existence value) are examples of benefits of nonuse goods. The use of the CV method to estimate such values could be highly controversial.

right of the improved service is initially with the provider, hence WTP is appropriate to use. The third issue is to decide on the type of elicitation question. The analyst can choose from a host of different elicitation questions such as open-ended questions, iterative bidding questions, contingent ranking questions, dichotomous choice questions, and payment card method. Certain questions will have a number of variants. For example, the dichotomous choice method can vary as being single bounded, double bounded, and triple bounded questions (Gunatilake 2003). Choosing among these question types is difficult as neither economic theory nor empirical evidence provides clear guidelines in selecting elicitation questions. Researchers⁸ frequently recommend the dichotomous choice method (Portney 1994) and its application in WSS projects has provided reliable results so far (Pattanayak et al. 2006).

Once the above issues are resolved, the analyst should carefully prepare the survey instrument for the CV study. The final questionnaire format is situation-specific, and therefore it is difficult to have a template to suit all situations. It is, however, customary to use a recent and relevant questionnaire as the basis to develop the survey instrument. Carefully designed purposive interviews and focus group discussions should be conducted prior to designing the survey instrument in order to understand the socioeconomic and cultural context. Preliminary versions of the instrument should be pretested with an adequate number of interviews before finalizing the questionnaire.

There is no common recommended content to a survey instrument. However, a CV survey instrument should generally have the following sections:

- (i) an introductory section, which provides the general context for the decision to be made
- (ii) a detailed description of the good to be valued
- (iii) the institutional setting under which the good will be provided
- (iv) the manner in which the payment is to be made (payment vehicle)
- (v) questions for elicitation of WTP
- (vi) debriefing questions about reasons for the given responses
- (vii) socioeconomic profile of the respondents

B. Minimizing Biases

Eliciting consumer preferences through interviews is not an easy or trivial task, as some analysts may tend to believe. The main challenge is minimizing many possible biases in CV studies, which could diminish the value of WTP estimates. Certain biases may occur depending on the way the sample was selected, questions were framed, and the survey was conducted. Sampling bias, common to any type of survey study, arises when the sample is not representative of the population. Some of the individuals selected through the sampling framework may not respond to the CV questions, resulting in nonresponse bias. If the nonresponse is purely random, the analysts can resolve this by increasing the sample size. The manner by which the interviewer asks the CV

⁸ For example, the US National Oceanic and Atmospheric Administration panel appointed to evaluate the appropriateness of CV methods to design compensations for environmental damages, which consists of four world-renowned economists (three of them Nobel laureates), recommended the dichotomous choice method.

question, and provides additional (voluntarily selected) information, may evoke a particular type of response resulting in nonneutrality bias. Proper training of enumerators and consistent supervision of CV studies during implementation are necessary to reduce this bias. Survey questionnaires should be free from any indication of the analyst's preferences. In some instances, the analyst's cultural background, including his/her own values, may influence the way the survey questions are framed and can thus evoke particular types of answers that are not reflective of the respondents' true preferences. A deeper understanding about the social, economic, and cultural context through background readings, focus group discussions, and purposive interviews can help the analyst maintain neutrality. In most circumstances, the CV respondents provide a nonbinding answer to a hypothetical question, which results in noncommitment bias. The analysts should strive to obtain committed answers through proper designing of the questionnaire and careful administration of the survey.

The analyst should also have a clear understanding of the social and cultural context and the educational background of the survey respondents, to ensure that they comprehend the CV questions. In an actual market situation, respondents can correct their mistakes in the next round of purchase if they make a wrong choice in the first. In contrast, CV surveys allow only one time choice and respondents have to make their judgment with limited prior knowledge about the proposed service. Therefore, respondents require having a certain level of cognitive ability in answering a CV question. To address this, the analysts should consciously design questions in a manner that respondents can easily assess the situation.

In estimating WTP for a number of public goods, the order by which these goods is arranged in the survey questionnaire and presented to the respondents can cause bias called the "order effect." In the case of environmental services, the first good presented is valued higher compared to others. In WSS CV studies, there is limited chance for this bias to occur. Studies have also shown that the final WTP estimates are sensitive to initial values (or bids) provided to the respondents. Respondents are likely to take the solicited amounts as initial clues of the values, especially when they are not familiar with the commodity being evaluated. This particular bias is known as the starting point bias, which is prone to occur particularly when the iterative bidding method is used.

The CV questions by definition are hypothetical; they describe a commodity that will be offered in the future. When respondents are unfamiliar with the commodity or do not have any previous experience with it, it is generally difficult to obtain reasonable answers. Using CV to value WSS services, despite it being a familiar commodity, can still have certain elements of hypotheticality. In order to reduce the hypothetical bias, the analyst should design the survey instrument in such a manner to ensure that (i) respondents are familiar with the good that is being valued; (ii) respondents are given experience in both valuation and choice procedure; and (iii) there should be as little uncertainty as possible about the details of the good. Under certain circumstances, WTP may not change with the varying quantities of the public good being valued (Kahneman and Knetsch 1992). For example, the respondent's WTP is the same or does not vary much if the good involves preserving one lake, two lakes, or three lakes. In CV literature, this bias is known as embedding effect. In addition, respondents may behave strategically and not reveal their true WTP in a CV study. This problem may be serious in the case of a public good where the respondents have the potential to free ride. Respondents may overbid if they believe their bid can influence the provision of the service. If they believe that service provision is not dependent on the bid level, they may

underbid, assuming they can receive the good at a lower price. Analysts should try to minimize elements that promote strategic behavior in their survey design. If there is clear evidence that a respondent answered strategically, that questionnaire can be excluded from the sample.

Most of the foregoing biases are common and serious in CV studies, especially those that attempt to value indirect use values or nonuse values such as bequest and existence values. However, many of these biases may not occur in WSS sector studies because WSS services are relatively familiar to the respondents. Moreover, a well-designed and carefully implemented CV study can effectively minimize most biases. Prior knowledge of the above biases and conscious effort to minimize them are crucial to obtain reliable WTP estimates for WSS projects.

C. Assessing Accuracy of CV Findings

To establish the accuracy of CV studies, the analyst should evaluate the survey responses by examining three aspects: validity, reliability, and precision. Validity refers to whether survey respondents have answered the question the interviewer attempted to ask. If respondents answered the right question, reliability refers to the size and direction of bias that may be present in the answers. Precision refers to the variability in responses. Increasing the sample size can simply increase the precision.

Validity can be divided into convergent validity and construct validity. Convergent⁹ validity generally refers to the temporal stability of WTP estimates. It can be assessed by examining the consistency of WTP estimates over time through repeated surveys of the same individuals. Other methods of assessing convergent validity include: (i) comparing WTP estimates with similar values derived from more reliable revealed preference data; (ii) comparing WTP estimates with respondents' actual behavior when they participate in experiments that simulate the market for the commodity in question; (iii) calibrating the respondents' valuation of goods by various ways to get more accurate WTP estimates; and (iv) comparing the WTP results obtained using different elicitation methods. From an operational point of view, examining convergent validity is not practically feasible during a PPTA CV study.

Construct validity refers to how well the measurement is predicted by factors that one would expect to be predictive a priori. Here the analyst can examine the consistency of CV results with the predictions of economic theory. Most CV studies provide WTP functions¹⁰ that relate respondent's WTP to the individual's characteristics and to the characteristics of the commodity. Hypothesis testing can be performed using the WTP function to test the construct validity. There are a number of relevant hypotheses commonly tested in CV studies. For example, economic theory suggests that the probability of wanting the commodity should decline as the price of the commodity increases. This effect is almost universally found in CV studies. Income usually has a positive effect on WTP. Age may have a negative effect while geographic proximity for an environmental service usually has a positive effect on WTP. Some variables may have a unique impact to the particular commodity being valued under specific circumstances. For example, a household located far from piped water supply may have a higher WTP because of the scarcity factor. Perception variables

⁹ Convergent validity can also be assessed when different estimates of WTP are obtained using different methods for the same sample at the same time.

¹⁰ The type of econometric models used in developing WTP function varies with the type of elicitation question. For example, the open-ended WTP format models WTP function with Tobit models, while dichotomous choice models use probit or logit models.

related to providing the commodity tend to predict the respondent's WTP in an expected manner. In particular, perceptions against the program's success in provision of the good, or attitude against the payment vehicle,¹¹ tend to be negatively associated with WTP. Testing the foregoing hypotheses can provide a high level of confidence about the construct validity and consequently, about the estimated WTP values. Construct validity can be feasibly tested during PPTA CV studies to establish the credibility of the WTP estimates.

III. CASE STUDY

A. Study Design

This section describes a case study. The Government of Sri Lanka considered the possibility of a PPP to provide improved WSS services in two service areas: Negambo and the coastal strip from Kalutara to Galle. As a part of the preparatory efforts, this study was undertaken by Research Triangle Institute International, USA in collaboration with University of Peradeniya, Sri Lanka with financial support from World Bank–Netherlands Water Partnership. While the overall study objectives were broader than estimating WTP for improved WSS services, this paper focuses mainly on the WTP aspects of the study.¹² After gathering and reviewing basic sector information, the authors developed the survey instrument through a series of focus group discussions; several purposive discussions with households and government (National Water Supply and Drainage Board and Water Resource Secretariat officials); and 120 pretests. The 69-page survey instrument comprised seven modules with split sample design for CV determination, and conjoint questions to gauge the household demand for improved WSS services (see Pattanayak et al. 2004 for a description of the survey instrument).

A three-stage stratified random sampling procedure was used to select 1,800 households from two divisional secretariats in Negambo, five coastal divisional secretariats in Kalutara, and 10 coastal divisional secretariats in Galle. The sample included households that are connected and unconnected to piped water. There were 15 enumerators for this survey, composed of recent graduates from the University of Peradeniya who were carefully selected and trained using a mixture of lectures, role playing, and field trials. Two field directors and three field coordinators supervised the conduct of the survey. The in-person (face-to-face) mode was used to conduct the survey, and each survey lasted approximately 50 minutes. Completeness and accuracy of the surveys were checked on a daily basis using a quality checklist. Overall, a great deal of care was exercised in designing and conducting the CV study to ensure accuracy (Pattanayak et al. 2004).

B. Willingness-to-Pay Estimation and Policy Simulations

In this study, WTP data gathered from the CV survey measures the amount of monthly income that the household is willing to give up to obtain improved water services, while remaining as well-off as before (see Appendix I for a theoretical exposition of the relationship of WTP to other welfare measures of project benefits). Willingness-to-pay, estimated in this manner, is a measure of the household's economic value (benefit) derived from improved water services. The study

¹¹ Tax is sometimes used as the payment vehicle in CV studies. If the respondents believe that tax money is generally misused or wasted by the government, such respondents tend to have lower WTP.

¹² The study covered both water supply and sanitation. This paper presents only the details related to water supply for a better focus.

used a single bound, closed-ended CV question to elicit household preferences. More specifically, households currently connected to piped water services were asked to consider an increase in monthly consumption charges for improved water supply service. Service improvement was accurately described as providing 500 liters of clean and safe water, 24 hours a day, with regular and fair billing based on metered use together with prompt repairs and efficient customer services. Based on this description, the survey sought consumer responses, either "yes" or "no", to different water bills for improved water services. Bid (i.e., monthly water bill) distribution was carefully chosen based on the information on current water bills, cost of improved services, and other relevant information gathered through focus group discussions and purposive interviews.

Table 1 shows the percentage of yes responses. Households without access to piped water were similarly asked to consider paying monthly consumption charges, with additional questions on connection charges for piped water services. As shown in Table 1, 83% of the connected respondents and 57% of the unconnected respondents, respectively, answered yes when they were presented the improved service with a Rs. 100 monthly bill. It should be noted that the answer to the WTP question does not directly provide WTP; if the answer is yes, WTP is equal or greater than the bid and if the answer is no, WTP is less than the bid.

TABLE 1
DISTRIBUTION OF YES RESPONSES TO CLOSED-ENDED CV QUESTION (PERCENT)

WATER BILL (BID) FOR IMPROVED SERVICE (Rs.)	CONNECTED (N=680)	UNCONNECTED (N=1138)
100	83	57
200	74	36
300	63	35
400	47	29
500	42	28
600	29	22
800	33	9
1000	14	15
Total	49	29

Two important observations can be made from Table 1. First, as the bid (monthly water bill) increases, acceptance (yes answers) by both connected and unconnected households decreases. This observation confirms the law of demand, i.e., demand for improved water services decreases as the monthly consumption charges increase. Second, acceptance of the bid is higher among those who are currently connected to piped water compared to those unconnected. This seems counterintuitive because usually, unconnected households should be willing to pay more. As many studies (e.g., UNDP 2006) reveal, the economic cost of water (through direct purchasing or time spent in collecting) for unconnected households is generally higher than that of the improved services. In this study, however, the situation is different because of two reasons. One is the availability of cheap and good quality substitutes, mainly well water; and the other is the affordability of connection charges. As will be shown later, excluding the connection charge substantially increases the unconnected households' WTP. Segregating the sample further to poor (first income quintile) and nonpoor (fifth income

quintile) groups shows substantially higher yes responses among the nonpoor for both connected and unconnected groups. This observation also demonstrates that households' responses conform with the economic theory of positive effect of income on WTP. These preliminary observations imply that certain construct validity expectations are met in this study.

Econometric analysis further demonstrates that the CV findings comply with construct validity. A multivariate probit regression model was estimated to analyze the survey data and to estimate the mean WTP. The development of a WTP function using an econometric model allows: (i) testing hypothesis on construct validity based on statistical significance; (ii) estimating the contribution of different household characteristics and other factors to the choice of the households; (iii) estimating the mean WTP; and (iv) generating a function for the out-of-sample prediction that is useful in transferring the benefits to other project sites. In this regression model, the households' reply (Yes = 1, No = 0) to the dichotomous choice elicitation question of WTP serves as the dependent variable. The independent variables consist of the bid; a set of economic variables (poverty status, connection cost); household data including location and distance to the road; availability of alternative sources of water; occurrence of diarrhea in the family; education level of the household head; and household perception-related variables such as perception on water pollution in the area and seriousness of water supply shortages.

The regression results in Table 2 confirm the previous finding that WTP for improved water services will decrease as the monthly water bill increases. Similarly, higher connection costs reduce WTP. Moreover, the results show that WTP is lower among the poor compared to the nonpoor households, which confirms the positive income effect on WTP. Those who receive remittances from abroad are willing to pay more while Samurdhi (the Sri Lankan Government's flagship poverty alleviation program) recipients show lower WTP. Those who consume more water are willing to pay more. As economic theory predicts, the availability of water substitutes, mainly wells with good quality water in this case, resulted in low WTP. The aforementioned results are consistent with economic theory. The other findings also agree with the conventional wisdom of human behavior. For example, distance to the road is positively related to WTP, which may be due to the fact that water is more scarce for households located far from the roads. The dummy variable related to location indicates that there are location differences in WTP. All the perception-related variables including education shows the expected relationship to the WTP.

The results of the probit regression thus sufficiently establish the construct validity of the CV study, i.e., there is correspondence between what was intended to be measured and what is actually measured. Altogether, these results indicate that the derived WTP estimates can be used for policy purposes with reasonable confidence. The probit regression results do not provide WTP directly. Mean WTP can be estimated using the coefficients of this regression model as described by Hanemann (1984), Cameron and James (1987), and Cameron (1988) (see Appendix II for the theory and procedure for estimating mean WTP using the probit regression results). Using this method, the mean WTP for the entire sample is estimated at Rs. 234 per month. The method also allows calculating the mean WTP for selected subsamples, which in this case is Rs. 357 per month for the nonpoor and Rs. 106 per month for the poor. The mean WTP for those connected to piped water is about three times higher than that of the unconnected. Given the pre-existing average tariff of Rs. 75 per month for a household, the mean WTP for improved service is much higher. However, the analyst should not rely exclusively on the mean WTP values because mean values may provide wrong policy directions.

TABLE 2
IMPACT OF HOUSEHOLD CHARACTERISTICS AND RELATED VARIABLES ON DEMAND FOR IMPROVED PIPED WATER SERVICE—PROBIT REGRESSION

VARIABLE	MEAN	COEFFICIENT	P-VALUE
Regression constant		1.119	0.000
Monthly consumption charge (Rs.)	487	-0.002	0.000
One-time connection cost (Rs.)	5,534	-0.00003	0.004
Monthly per capita consumption (Rs.)	6,044	0.00003	0.004
Household receives remittance (1 = yes; 0 = no)	0.10	0.276	0.013
Household is a Samurdhi recipient (1 = yes; 0 = no)	0.19	-0.245	0.012
Household head is employed in private sector (1 = yes; 0 = no)	0.41	0.213	0.002
Distance to road (kilometers)	0.32	0.112	0.134
Household resides in Greater Negombo (1 = yes; 0 = Kalutara or Galle)	0.45	-0.484	0.000
Household resides in Kalutara (1 = yes; 0 = Greater Negombo or Galle)	0.23	-0.326	0.000
Percent of households with access to private wells in Greater Negombo	0.79	-0.329	0.014
Percent of households that consider water quality of their alternative sources as excellent or good in Greater Negombo	0.59	-0.312	0.013
Household believes that there is a water contamination problem (1 = yes; 0 = no)	0.10	0.248	0.023
Household thinks government should give connection subsidy to low-income households for improved water supply services (1 = yes; 0 = no)	0.30	0.025	0.731
Household is particularly conscious of institutional issues (1 = yes; 0 = no)	0.01	0.570	0.040
Private sector will provide improved service (1 = yes; 0 = public sector will provide)	0.55	-0.116	0.085
Household is particularly conscious of health issues (1 = yes; 0 = no)	0.02	0.648	0.003
Household has experienced a case of morbidity event (1 = yes; 0 = no)	0.02	0.649	0.006
Household is Tamil (1 = yes; 0 = no)	0.03	-0.475	0.047
Household owns the house (1 = yes; 0 = no)	0.94	-0.322	0.025
Education of household head (years)	9	0.021	0.090
Number of observations		1735	
Likelihood ratio statistic χ^2 (20)		389	0.000
Percent responses correctly predicted		73	
Log likelihood		-942	

C. Use of WTP Estimates and Policy Simulation

The estimated WTP values have a number of important uses such as calculating the benefits of the proposed improvements to the water supply system, tariff setting, and making informed decisions on related policy issues of the WSS project. Calculating project benefits using WTP estimates is straightforward. Once the analyst gets reasonable confidence about the estimated mean WTP value, it can be readily used in project economic analysis. The mean WTP multiplied by the number of households served by the project provides the total gross benefit of the project.

The use of WTP estimates in setting tariffs is also reasonably straightforward, but some understanding is required to avoid its misinterpretation and misuse. CV surveys provide measures of the maximum WTP for proposed improvements in WSS in the context of the existing or proposed institutional regime. The WTP is related but not equal to the future demand or monthly bill paid by the households to the water utility (see Appendix I). Although future demand and WTP contain similar behavioral information on household preferences, WTP is different because it is an *ex ante* measure of welfare change associated with the improved WSS. It will not show how much water will be consumed when services are improved, or how many households will be connected to the improved service with a revised tariff and connection charges. Therefore, WTP cannot be used to estimate revenue directly, because households will pay only a proportion of the maximum WTP expressed in the CV study. Moreover, basic economic principles suggest that monthly charges should be equal to or less than WTP. Therefore, a tariff that charges above WTP will lead to welfare losses and may discourage households from connecting to the water services. Therefore the WTP should be treated as the upper bound of tariff. Furthermore, tariff setting requires additional information because it requires meeting a set of social, economic, and financial goals such as good governance, financial sustainability, economic efficiency, and distributive justice/fair pricing (Dole 2003, Dole and Bartlett 2004, Dole and Balucan 2006). In addition to WTP therefore, information on the cost of delivery, capital replacement requirements, and various social considerations should be used in setting tariffs.

The estimated WTP functions can also be used to analyze additional policy issues related to designing WSS projects such as the choice of the provider, design of spatially based pro-poor service delivery, affordability, and characterizing the low WTP groups. The study implicitly assumed that households prefer the private sector as the service provider, believing that they can benefit more through efficient operation and maintenance. In order to assess households' preference toward the provider, the study used a split sample approach. About half of the sample was told that the improved service will be provided by the private sector, while the rest was told that the reformed public sector will improve the service. A dummy variable was used to analyze households' attitude toward the service provider. A statistically significant negative coefficient (see Table 2) indicates that, holding everything else constant, households will have a lower probability of connecting to the improved services if the private sector provides the service. This shows that households' perceptions are against generally held beliefs about the desirability of private sector provision of WSS.

The study also explored the possibility of designing pro-poor service delivery. Toward this end, the WTP for each household in the sample was calculated using the regression model. This study mapped all the surveyed households using geographic positioning systems (GPS).¹³ Mapping allowed

¹³ Every enumerator was given a GPS unit and instructed to locate the household using the GPS unit after the interview.

the investigation of any low WTP clusters or any other type of spatial patterns of clustering of WTP. Two poverty maps for the two service areas were drawn using the survey data and sample-specific poverty definitions. These maps were overlaid with WTP maps to examine whether there is any particular pattern that could be used to design spatially based, targeted pro-poor service delivery designs. The maps did not show any distinct spatial clustering, thus there was no basis to identify localities with high intensity of poverty and low WTP. Therefore, the design of pro-poor special delivery on the spatial clusters was not feasible in this case.

The study also performed simulations to assess the affordability of the poor, using one-time connection charge as the policy lever. The impact of connection charges on WTP was evaluated by simulating an econometric model with different levels of connection charges. Tables 3 and 4 show WTP for improved water services from a private provider for both connected and unconnected households, segregated further into poor and nonpoor. The simulation results in Table 3 assume zero connection fees for currently connected households and a Rs. 6000 one-time fee for unconnected households, while Table 4 assumes zero connection fees for all the households. Thus, the differences in WTP of the two tables are due to connection charges. Comparing these tables clearly shows that WTP is significantly higher if the connection charge is set to zero (i.e., connections are subsidized). WTP is very low among unconnected households when they have to pay connection charges. In the absence of any subsidy, unwillingness to connect to the new system will have serious implications on the viability of the proposed PPP.

TABLE 3
WTP ESTIMATES BY SUB-GROUPS WITH CONNECTION FEES OF RS. 0 FOR CONNECTED
AND RS. 6,000 FOR UNCONNECTED HOUSEHOLDS

DISTRICT	FIRST QUINTILE (N = 365)	FIFTH QUINTILE (N = 362)	OVERALL (N = 1818)
	MEDIAN		
Gampaha (Greater Negombo)	105	250	150
Connected	215	515	425
Unconnected	10	145	55
Kalutara - Galle	180	470	310
Connected	255	490	405
Unconnected	120	385	200
Overall	160	390	250
Connected	245	500	410
Unconnected	100	215	115 ¹⁴

¹⁴ The simulation was performed with a different, simplified regression model. Therefore the WTP value in Tables 3 and 4 are only indicative.

TABLE 4
WTP ESTIMATES BY SUBGROUP WITHOUT CONNECTION FEES

DISTRICT	FIRST QUINTILE (N=365)	FIFTH QUINTILE (N=362)	OVERALL (N=1818)
	MEDIAN		
Gampaha (Greater Negombo)	215	505	400
Connected	215	515	425
Unconnected	210	500	385
Kalutara - Galle	310	550	440
Connected	255	490	405
Unconnected	320	745	480
Overall	290	520	425
Connected	245	500	410
Unconnected	300	570	430

The PPP designers assumed that improved services will be accepted by the community, with about 95% of the households connecting to the improved WSS system. The investment plan; number of hours of supply; and consequently the capacity of the plants, revenue levels, and subsidy requirements were all dependent on this assumption. To understand the households' preference to get connected (for unconnected households) or remain connected (for connected households) the study simulated the regression model presented in Table 2. The simulation results in Table 5 indicate that the predicted uptake rates¹⁵ are much lower than 95%. Removal of the connection charges showed significant increase in uptake rates. Even with no connection and monthly charges, however, about 30% of the poor did not want to get connected. This implies that poor households may be incurring certain implicit transaction costs when getting private water connections.

TABLE 5
PREDICTED UPTAKE RATES OF IMPROVED WSS PROVIDED BY PRIVATE SECTOR (PERCENT)

SERVICE AREA	UPTAKE RATE	
	POOR	NONPOOR
Greater Negambo		
Connected	49	64
Unconnected	32	47
Kalutara-Galle		
Connected	44	59
Unconnected	27	42

The simulation exercises also showed a number of characteristics pertaining to subgroups that have a lower WTP, namely that they are (i) currently unconnected, (ii) poor, (iii) happy with the quality of existing water source, (iv) house owners, and (v) less educated. Underlying these

¹⁵ The uptake rates in Table 5 show percentage of households in each category that are willing to get the connection/ remain connected to receive improved water service with increased bills.

characteristics is mainly the issue of affordability. In addition, this subgroup has a reliable system of self-provision of water. Their WTP for improved water service is also influenced by lower incidence of water-related diseases, lack of perceived link between personal health and water quality, and overall satisfaction with the current supply. Overall, these findings show that there is much less demand for improved WSS in the study area than anticipated by the PPP designers. The above analyses indicate quite a different picture about the feasibility of the proposed project, compared to that indicated by the mean WTP.

D. Unbundling the Demand: Conjoint Analysis

Many CV studies in the past have focused, almost exclusively, on charges as the primary factor that determines demand for WSS. However, there is emerging evidence from other service industries that besides charges, consumers value multiple service attributes (Eto et al. 2001). The elicitation question used in this study to estimate WTP described water supply as a composite commodity with a number of attributes. It described the improved water service with five attributes: (i) cost (monthly water bill); (ii) quantity (500 liters per day); (iii) quality (safe to drink directly from the tap); (iv) reliability (duration of supply, 24 hours a day); and (v) service quality (regular and fair billing based on metered use, together with prompt repairs and efficient customer services). In the elicitation question, these attributes are fixed at levels that the analyst assumes are preferred by the households. The estimated WTP values therefore, do not reveal household preference for different levels of these attributes, rather, they correspond to some fixed level for each attribute. The analyst's assumptions on the attributes may not necessarily be realistic. This section describes how WTP can be estimated for each attribute through the use of a variant of CV method called conjoint analysis. This section illustrates how demand can be unbundled to different attributes that can be helpful in designing better service delivery, balancing the costs of providing different levels of attributes with tariff, and enhancing consumer demand for improved WSS.

Conjoint analysis¹⁶ is originally used in marketing research to value different attributes of a commodity. It has become increasingly popular due partly to the validity concerns identified in some CV studies (Adamowicz et al. 1999), and the additional information it can provide for policy purposes. Conjoint analysis treats commodities as a combination of a series of attributes offered at varying levels. Using conjoint analysis, analysts can determine the relative importance of the different attributes and their levels, and the probability that individuals select different combinations of attributes and levels. Random utility theory provides sound economic theoretical basis for conjoint analysis. Readers interested in the theoretical foundation of conjoint analysis may see Adamowicz et al. (1999) for a generic description and Yang et al. (2006) for an application to WSS.

The first step in undertaking a conjoint analysis is to define the attributes of the commodity in question and the levels at which they can be preferably consumed. For this study, the relevant attributes identified are the monthly water bill (cost), hours of supply, water quality, volumetric

¹⁶ Some authors use the term choice experiment for conjoint analysis. This method measures the WTP for different attributes. For example, a car company can estimate consumers' WTP separately for options such as central locking, leather seats, body color, air bags, engine size, etc. using this method. Information generated through conjoint analysis helps the car company to design the most desired types of cars by combining different features and pricing them according to the consumers' WTP. The same principle can be applied in designing water supply services.

consumption, and service alternative. These attributes were chosen based on the findings of focus group discussions, purposive interviews of households, and meetings with relevant government officials. Table 6 presents the attributes and their levels used in this study.

TABLE 6
WATER SUPPLY SERVICE ATTRIBUTES AND LEVELS

ATTRIBUTE	LEVELS		
Service option	Private water connection	Small diameter mini-grid	Metered standpost
Consumptive volume	600 liters per day 800 liters per day 1000 liters per day	200 liters per day 600 liters per day 1000 liters per day	200 liters per day 400 liters per day 600 liters per day
Supply hours	12 hours a day 16 hours a day 24 hours a day	4 hours a day 12 hours a day 24 hours a day	4 hours a day 8 hours a day 12 hours a day
Safety	Straight from the tap Only after filtering Only after boiling	Straight from the tap Only after boiling Only after boiling, filtering and treating	Only after boiling Only after filtering and boiling Only after boiling, filtering and treating
Monthly water bill	200 rupees 500 rupees 800 rupees	25 rupees 100 rupees 600 rupees	25 rupees 50 rupees 100 rupees

The next step in conjoint analysis is to develop an appropriate experimental design. The attributes and levels together give a large number of choice sets. The entire choice set can be too large to be accommodated in a conjoint study. Moreover, certain choices can be meaningless. For example, a 24-hour supply of highest quality water with highest consumption level together with best service quality cannot be provided with a very low monthly bill. Such illogical or impractical choices should be removed from the conjoint experiment. The experimental design selects a subset of choices to be used in the conjoint experiment. In this case, a D-optimal¹⁷ experimental design was used (see Zwerina et al. 1996 for details). Table 7 shows a sample conjoint question derived from the experimental design.

¹⁷ This design minimizes the geometric mean of the covariance matrix of the parameters of the conditional logit regression model to be estimated, to analyze the conjoint data and to estimate WTP for each attribute.

TABLE 7
A SAMPLE CONJOINT ANALYSIS QUESTION

	ALTERNATIVE 1	ALTERNATIVE 2	ALTERNATIVE 3
Service option	Private water connection	Small diameter mini-grid	Metered standpost
Liters per day	800	1000	600
Supply hours per day	24	4	8
Safe for drinking	After boiling	Straight from the tap	After filtering, boiling, and treating
Monthly water bill (Rs.)	500	100	50

What do you think your household would do?

(1) keep connection to the water supply network,

(2) connect to the small diameter mini-grid,

(3) rely on the metered standpost, or

(4) would you choose none of the above and continue to use your present water sources?

One advantage of conjoint question over the CV question is that it enables extracting more information from the same sample, because it provides more than one choice to a household in an interview. In this study, there were 27 unique tradeoffs grouped into nine blocks; each respondent was presented with one block of three choices with four levels of attributes each. Thus sample respondents answered 5,404 questions, which generated 21,616 observations compared to 1,735 observations generated by the CV question in Table 2. The responses for the given choices were modeled using a conditional logit model to estimate WTP for each attribute. Table 8 shows the results of conditional logit model.

Overall, the results of the conjoint analysis confirm that besides monthly charges, household demand is influenced by other service attributes. As expected, a higher monthly bill generates negative utility¹⁸ for the households. Volume of water and number of supply hours increase the utility of the households. Hours of supply, however, show diminishing marginal utility as indicated by the negative coefficient of the square term. As expected the quality of water has a positive impact on utility. Among the service options proposed, private taps and mini-grids are preferred over public stand posts. More interestingly, the results show that about 45% of households prefer their current source in comparison to all the proposed options. This finding further confirms that the demand for improved water services is much less than originally anticipated.

In order to examine whether the preferences differ among the poor and nonpoor, a set of dummy variables were used in the regression model. The results show that there is a difference in overall preferences between the poor and nonpoor. However, preferences do not differ for certain attributes. The poor have higher marginal utility of income, prefer stand posts over private taps,

¹⁸ Here the utility refers to overall welfare or satisfaction of the household, not to the provider that supplies the WSS service.

and also prefer mini-grids over public taps. The poor's preference with respect to hours of supply, volume, and safety is however, not different from the nonpoor.

TABLE 8
ATTRIBUTES OF SERVICE ALTERNATIVES - CONDITIONAL LOGIT MODEL FOR CONJOINT ANALYSIS

VARIABLE	MEAN	COEFFICIENT	P-VALUE
Proposed monthly water bill (Rs.)	216	-0.003	0.000
Volume of water per day (liters)	450	0.0004	0.000
Hours of water supply per day (number of hours)	10	0.039	0.024
Squared hours of water supply per day	161	-0.001	0.053
Water is safe for drinking straight from the tap (1 = yes; 0 = no)	0.18	0.840	0.000
Water is safe for drinking only after filtering (1 = yes; 0 = no)	0.08	0.468	0.000
Water is safe for drinking only after boiling (1 = yes; 0 = no)	0.23	0.396	0.000
Water is safe for drinking only after filtering and boiling (1 = yes; 0 = no)	0.08	0.246	0.037
Private tap dummy (1 = yes; 0 = mini grid or standpost)	0.25	1.223	0.000
Mini-grid dummy (1 = yes; 0 = private tap or standpost)	0.25	1.058	0.000
Household chooses to opt out (1 =yes; 0 = no)	0.25	2.005	0.000
POOR*Proposed monthly water bill	43	-0.001	0.030
POOR*Volume of water per day	90	0.00005	0.834
POOR*Hours of water supply per day	2	-0.0002	0.997
POOR*Squared hours of water supply per day	32	-0.0001	0.924
POOR*Water is safe for drinking straight from the tap	0.04	-0.019	0.915
POOR*Water is safe for drinking only after filtering	0.02	0.272	0.322
POOR*Water is safe for drinking only after boiling	0.04	0.128	0.408
POOR*Water is safe for drinking only after filtering and boiling	0.02	-0.107	0.636
POOR*Private tap dummy	0.05	-1.081	0.000
POOR*Mini-grid dummy	0.05	-0.581	0.000
POOR*Household chooses to opt out	0.05	-0.492	0.080
Number of observations		21,616	
Likelihood ratio statistic $\chi^2(11) / \chi^2(22)$		2464	0.000
Log likelihood		-6260	

The conditional logit model can also be used further to calculate the marginal WTP (MWTP) for each attribute. Estimated coefficient for the attributes can be divided by the marginal utility of money (coefficient of the monthly bill) and multiplied by -1 to obtain the MWTP. Table 9 shows the MWTP for different attributes. MWTP for an increase of supply by one liter is Rs.0.13. Given that the mean is close to current volumetric consumption of water, additional supply should have a lower MWTP, as shown by the results. Hours of supply also has a lower MWTP. Together with diminishing marginal utility of hours of supply, this result indicates that a 24-hour supply may not be demanded by the households, as perceived in the design of the PPP. Instead, households are willing to pay reasonable amounts for water quality as indicated by the results. The lowest quality (drink only after treating, filtering, and boiling) was taken as the reference point in the dummy variable analysis. As the water quality increases, MWTP gradually increases and a household is willing to pay Rs. 280 per month, on average, for the best quality water, all else remaining constant. This type of information is useful for the service providers to design a water service that caters to households' preferences.

TABLE 9
MARGINAL WTP FOR DIFFERENT ATTRIBUTES OF WSS

ATTRIBUTE	MEAN	MARGINAL WTP, RS.
Water volume (liters)	450.00	0.13
Hours of supply (hours per day)	10.00	13.00
Water quality		
Straight from the tap	0.18	280.00
Only after filtering	0.08	156.00
Only after boiling	0.23	132.00
Only after boiling and filtering	0.08	82.00

The foregoing results demonstrate the usefulness of conjoint analysis in understanding consumer preferences better. The results clearly show that household preferences do not depend only on the monthly charges, but on a variety of attributes of the WSS service. Some attributes are equally preferred while other attributes are preferred differently by the poor and nonpoor. Service programs with similar attributes of volume, hours of supply, and safety can be provided to both poor and nonpoor groups. Moreover, the findings of conjoint analysis can be used to make informed decisions on service delivery design. For example, it is clear that households do not value a 24-hour water service. Therefore, designing a water supply scheme with this in mind would have wasted resources. The study shows that households' WTP is small for additional water volumes and service hours, but significantly higher for water quality. Service providers should ensure that water is provided at good quality for which consumers are willing to pay more. Because a water utility incurs numerous costs in providing different attributes at various levels, designing the service delivery according to what consumers prefer will help avoid unnecessary costs.

E. Tariff and Viability of the Public–Private Partnership

The following illustrates how the findings of the CV study, together with secondary information, can be used to examine the overall viability of the PPP. As mentioned earlier, this study was conducted to buttress the information base for designing a PPP to provide improved WSS in two service areas of Sri Lanka. This PPP was initiated based on a number of assumptions. The government's intention was to attract private investors, preferably in consortium with international water companies. The proposed contracts were to last for 15 years. The operators would be remunerated, as specified in the contracts, by a fixed operator tariff for every cubic meter of water delivered and sold to the consumer. According to the initial design, the operator collects revenue from the consumers on behalf of the government. The operator retains its fee, and remits the difference to the government, which then uses its share in turn to pay for the investment in the system. The proposed PPP had planned to charge connection fees differently in the two service areas. In Negambo, connection charges were to be subsidized, while in the other area the consumers were to pay the full cost of connections.

The proposed contract had the following features:

- (i) *Universal service obligation.* The government's objective was to extend piped water service in two service areas to 95% of the population. Given the pre-existing coverage of 38% of households with access to piped water in the study area, this was an ambitious target.
- (ii) *Service performance specification.* The levels of services were to meet certain standards including 24-hour supply, with water quality that conforms to Sri Lankan standards.
- (iii) *Tariff and subsidy policy.* Investment needs were large if a 95% coverage target were to be met. Tariffs would need to be increased significantly (i.e., up to 100% of the pre-existing tariff) if operators were to realize a reasonable return on investment. The government planned to raise tariffs gradually and provide subsidies until the tariff is increased adequately.
- (iv) *Tariff structure.* The government wanted to maintain the pre-existing tariff structure, i.e., increasing block tariff assuming this benefits the poor.

The findings of this study provided valuable information to further understand the overall viability of the proposed PPP. First, in terms of service obligation, universal coverage may not likely be achieved in the two service areas, given the predicted uptake rates (see Table 5 in Section IIC). Second, the 24-hour supply assumption was unrealistic. As shown earlier, the hours of supply shows a positive relationship to household utility, but with diminishing marginal utility. Further analysis showed, through use of a dummy variable in the model presented in Table 2, that there is no significant gain to households by increasing water supply beyond 12 hours. This is also evident from the lower MWTP for hours of supply expressed in Table 9. The assumption that households prefer a 24-hour water supply clearly does not hold. Therefore, a service provision that includes this assumption in its design would have reduced social welfare if associated incremental costs were added to the tariff. On the other hand, the analyses show that progressively safer and better quality of water generates greater utility. The preference of the poor for water quality is not different from that of the nonpoor. Thus, the assumption that people have greater demand for better water quality seems to hold.

Third, the forecast of the tariff increase has not taken into account the price elasticity of demand. In effect the PPP design group has calculated the necessary tariff increase assuming zero price elasticity. Nauges and van den Berg (2006) estimated price elasticity for piped water to be -0.74 , using the data collected in this survey. Even though demand is inelastic, the numerical value is high (close to 1), perhaps due to the availability of reasonably good substitutes. According to the assumption of the PPP designers, a 1% increase in tariff will provide a 1% increase in revenue. However, when the price elasticity is taken into account, a 1% increase in tariff will result in much less than 1% increase in revenue. In this case therefore, the required tariff increase would be much higher than anticipated, if the private sector operations are to be financially viable. Disregarding price elasticity often leads to unanticipated tariff increases after commissioning the PPP. When the underlying assumptions of PPP tariff design are unrealistic, projects may experience costly failures. For example, 63 out of 89 water concessions in five Latin American countries had to be renegotiated in the 1990s due to inadequate understanding of basic demand features (Guasch and Straub 2003). Such renegotiations and consequent tariff increases often result in consumer welfare losses or costs to taxpayers, undermining the political will to privatize public utilities.

Fourth, the study provided additional insights to affordability analysis and pro-poor service delivery. The existing monthly tariff levels in 2003/2004 were affordable,¹⁹ even for the poor, as monthly water bill of the poor was less than 1% of the median consumption expenditure.²⁰ The government wanted to retain the increasing block tariff structure, assuming that it provides service to the poor at subsidized rates. In this case, the existing tariff structure subsidized almost all domestic users, while the utility was not recovering its full cost.²¹ The tariff structure was designed to subsidize households that use less than 20m³ per month. Interestingly, the average consumption of households that have access to private piped water connections was only 19m³ per month, and the difference in consumption between the poor and nonpoor was small. Moreover, only 28% of the poor are connected to the service. That the nonpoor was benefiting from the subsidy is further illustrated by the benefit targeting performance indicator (BTPI).²² If the BTPI is less than 1, it implies that the poor do not receive a higher proportion of the benefits. van den Berg et al. (2006) estimated BTPI to be 0.75. Thus, the consumption subsidies were not effective in targeting the poor. The connection fee, as discussed earlier, provides a better avenue to target the poor. BTPI for subsidies on connection charges is estimated to be 1.20. Hence, subsidy on connection charges is a better way to target the poor.

Overall, the study shows that the proposed PPP is not feasible because many of the implied assumptions do not hold. While these findings cannot be generalized to other locations, they provide a valuable lesson, that is, the importance of thoroughly investigating demand for WSS and the basic assumptions that underpin WSS projects. The government decided later not to implement the proposed PPP due to political reasons. This decision avoided the implementation of a project that had a higher chance of not achieving its objectives.

¹⁹ Many studies, including this, reveal that affordability analysis that considers only the monthly tariff (ignoring the connection charges), is of limited help in designing pro-poor WSS projects.

²⁰ In addition to the CV and conjoint analysis findings, other available secondary information is very useful in making informed decisions on WSS projects. Authors found that additional secondary information was extremely useful in this study.

²¹ The Water Supply and Drainage Board was recovering only a portion of the operating costs all over the country except in the Colombo municipality area.

²² This indicator measures the share of subsidy benefits received by the poor divided by the proportion of poor individuals in the total population.

IV. CONCLUDING REMARKS

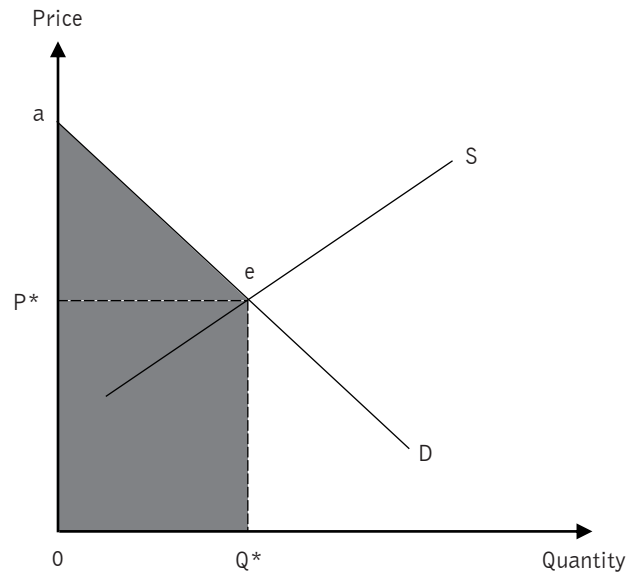
The purpose of this paper is to show the usefulness of well-designed and carefully implemented WTP studies in the preparation of WSS projects. Once the validity and reliability of such studies are established, the study findings can be used to make informed decisions on a number of aspects of project design, besides provision of project benefit estimates. More specifically, the paper shows how to generate useful supplementary information on household preference on the provider of WSS, affordability and uptake rates with different connection charges, and feasibility of pro-poor service delivery. Moreover, it shows how to use conjoint analysis for better understanding the demand. Furthermore, the paper illustrates the use of WTP study findings together with other reliable secondary information to assess the overall viability of WSS projects. Thus, the paper demonstrates good practices that can be used in ADB WSS project preparation.

APPENDIX I DEMAND, PROJECT BENEFITS, AND WILLINGNESS-TO-PAY

This appendix explains the relationship among demand, project benefits, and WTP. Demand generally refers to the relationship between the price and quantity of a commodity, and the demand curve shows the prices people are willing to pay for different quantities of the commodity, holding income and related prices¹ constant. The gross benefit of producing a commodity for society is represented by the area under the demand curve. Since the quantity demanded is curtailed at the market price, the commodity is not produced beyond the equilibrium quantity. Therefore, the gross benefit to the society of producing the equilibrium quantity is given by the shaded area in Figure A1. Note that the gross benefit includes revenue (area of op^*eq^*) and consumer surplus (area of ap^*e).

¹ Prices of substitutes and complements are referred to here as related prices.

FIGURE A1
GROSS ECONOMIC BENEFITS OF PRODUCING A COMMODITY



The shaded areas of Figures A2 and A3 show the gross benefit of a project that increases supply of the commodity. Note that project output Q' shifts the supply curve resulting in a new equilibrium. When the quantity supplied by the project is small relative to the total quantity in the market, the project's output does not influence the market price. Project revenue, as depicted by the shaded area in Figure A2, provides the gross benefit of the project under this circumstance. Gross project benefits equal project revenue plus the net social surplus² when the project output is large enough to influence the market price. In the case of a price decline as shown in Figure A3, the project's gross benefit has an incremental component (lightly shaded) and nonincremental (darkly shaded) component.³

² The social surplus is the sum of consumer surplus and producer surplus.

³ See ADB's *Guidelines for the Economic Analysis of Projects* (ADB 1997) for details. These measures assume undistorted markets.

FIGURE A2
GROSS BENEFIT OF A PROJECT OUTPUT WITH NO PRICE EFFECTS

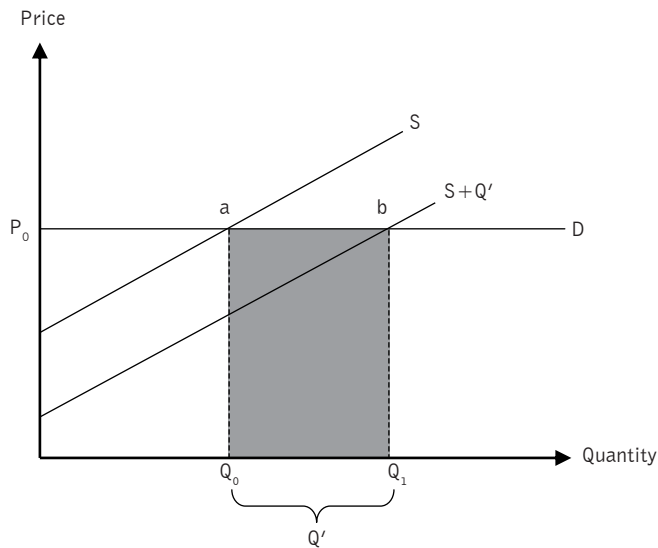
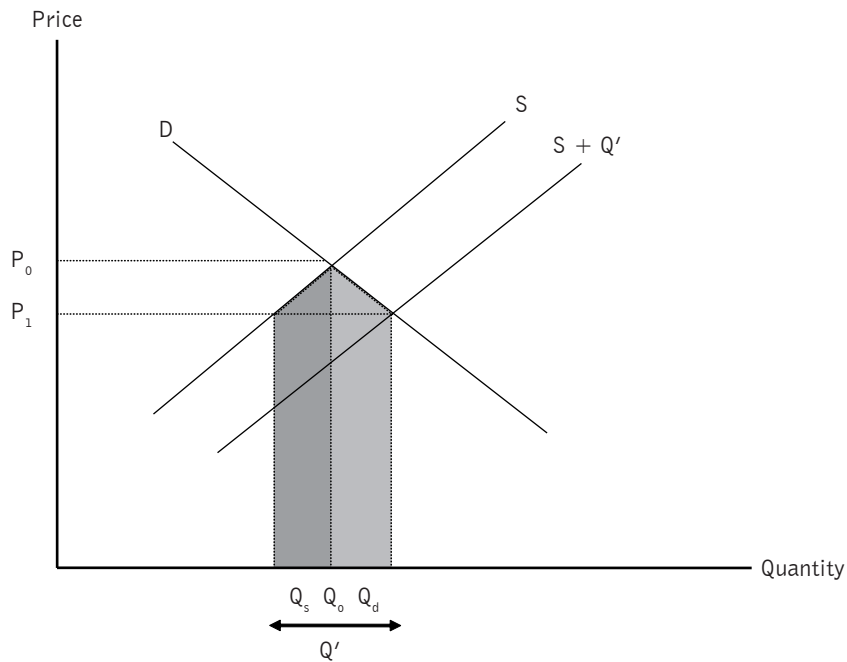


FIGURE A3
GROSS BENEFIT OF A PROJECT OUTPUT WITH PRICE EFFECTS



Use of the abovedescribed measures to value project benefits is feasible when information on market demand (revealed preference information) is available. The project benefit measures shown in Figures A2 and A3 are however, only approximations of the theoretically correct measures of project benefits. The theoretically correct measures of project benefits should directly reflect the utility changes associated with the increase

of supply of the commodity by the project. The market demand curve, known also as the Marshallian demand, does not accurately reflect the utility changes associated with increased supply of the commodity by the project. Compensating variation or equivalent variation measures are the theoretically correct measures of project benefits. Of the two measures, compensating variation is the relevant measure in valuing project benefits using the CV method. Therefore, the discussion here limits to compensating variation.⁴ The maximum amount of income the household is willing to give up in order to acquire a commodity while remaining at the same utility level is defined as compensating variation. This is theoretically correct because it directly measures utility change in money metric terms. In a CV study, the analyst frames the elicitation question to obtain the compensating variation.

Although the benefit estimated using Marshallian demand curves (as shown in Figures A2 and A3) are not theoretically correct, they are closely related to the compensating variation. A simple indifference curve analysis can be used to explain the relationship between Marshallian measures of project benefits and compensating variation. Assume in the indifference curve in Figure A4 that price of the commodity in the Y axis is unity.⁵ The X axis represents the quantity of WSS, and the budget line GH represents the situation before purchasing⁶ the improved WSS. The improved WSS leads to a higher price and to a new budget line of GI if household income is constant. If additional income is not available, the equilibrium consumption shifts to point b from point a. Notice that at point b households' utility level is lower compared to that at point a. If the household has additional income⁷ to spend on the improved WSS, it can move to point c and retain the same level of utility by sacrificing the amount of income equal to GJ, which is the compensating variation. If properly measured, the CV survey can directly estimate GJ. Therefore, the WTP estimate provides the theoretically correct measure of gross benefit of improved WSS to the household.

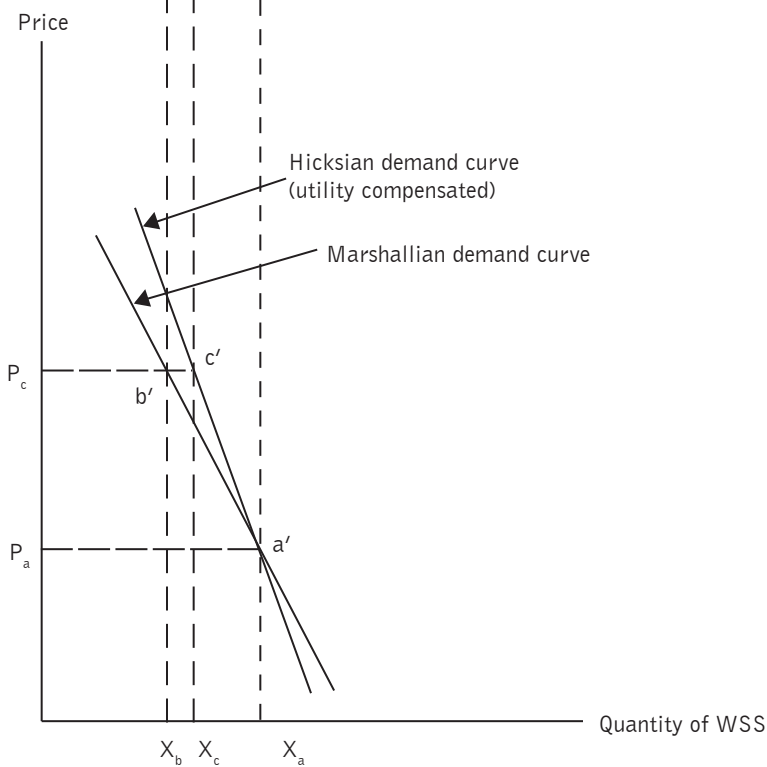
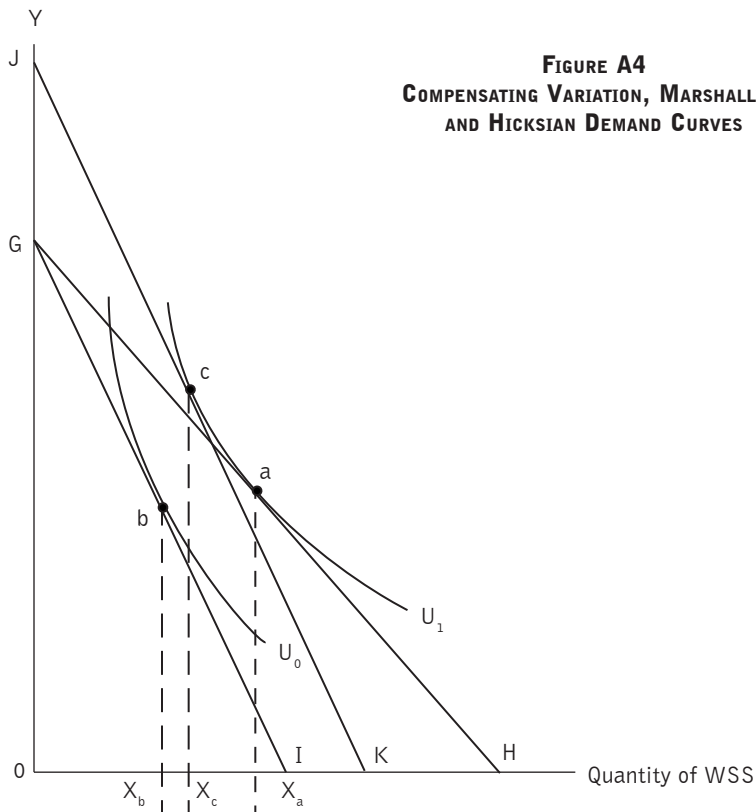
⁴ The difference between equivalent variation and compensated variation lies on the reference utility level of the Hicksian demand function. If the original utility level is used as the reference point it results to compensated variation. Property right of the status quo also makes the difference in the two measures (see Gunatilake 2003 for details). For project benefit valuation, compensated variation is the correct measure since the CV question attempts to keep the original utility level constant.

⁵ This allows for ready conversion of the quantities in the Y axis to income.

⁶ If the respondents in the CV survey answer truthfully, accepting the bid can be treated as equivalent to purchase of the improved WSS.

⁷ Another way to look at the additional income is to assume that the household is compensated for the utility loss.

FIGURE A4
COMPENSATING VARIATION, MARSHALLIAN
AND HICKSIAN DEMAND CURVES



The lower panel of Figure A4 shows two demand curves derived from the changes depicted in the indifference curves. Consumption change from a to b gives us the usual Marshallian demand curve whereas the utility compensated change (a to c) gives another demand curve. The latter is known as the Hicksian or compensated demand curve. The WTP measured as distance GJ can also be measured as the relevant areas under the demand curves in the lower panel of Figure A4. However, the two demand curves will provide different estimates: the Marshallian demand curve above point a' underestimates⁸ benefits, whereas it overestimates benefits below a' .

In order to get the theoretically correct measure of the benefits, the relevant area under the Hicksian demand curve should be used. Unfortunately, the Hicksian demand curve cannot be estimated because utility is an argument of the Hicksian demand function. Therefore, benefit estimates are usually obtained from the observable⁹ Marshallian demand curves. As mentioned earlier, income is held constant in the Marshallian demand curve and therefore it does not reflect project benefits accurately. If the income effects¹⁰ are relatively small, however, the errors involved in Marshallian benefit measures are small. Under most circumstances the Marshallian project benefit measures shown in Figures A2 and A3 provide close approximations.¹¹ Therefore, the benefits derived from Marshallian demand curves are widely used in project economic analysis. Despite the WTP being a theoretically accurate concept, measuring it through direct interviews is challenging. Therefore, use of Marshallian measures is encouraged whenever market demand information is available. When market demand information is not available, cautious use of the CV method to estimate project benefit is recommended.

⁸ Marshallian demand may underestimate or overestimate the benefits depending on whether welfare change associated with price increases or decreases, and depending on the reference utility levels.

⁹ Marshallian demand can be estimated using econometric methods incorporating price, quantity, and other relevant data.

¹⁰ When income elasticity is zero, Marshallian and Hicksian demand curves become the same.

¹¹ Willig (1976) shows that errors of using Marshallian surpluses are small under most circumstances.

APPENDIX II ESTIMATION OF MEAN WTP FROM CLOSED-ENDED CV DATA

This appendix explains the theory and procedure for estimating mean WTP using the data generated through dichotomous choice (closed-ended) elicitation method. Theory behind the estimation of mean WTP is explained first. Assume that the household's utility depends on a composite commodity X^{12} and leftover money (Y) available for paying a water bill. Utility has a deterministic component (first and second terms of the right hand side of the equation 1) and a stochastic component, ε . Utility of the household before answering the CV question is:

$$u_0 = X_0\beta + \gamma Y + \varepsilon_0 \quad (1)$$

Utility of the household can be given by equation (2) if the household answered¹³ yes to the CV question, where WTP is the maximum amount of money the household is willing to give up to obtain the improved WSS services.

$$u_1 = X_1\beta + \gamma (Y - WTP) + \varepsilon_1 \quad (2)$$

By subtracting (2) from (1) we get:

$$u_0 - u_1 = (X_0 - X_1)\beta + \gamma WTP + \varepsilon_0 - \varepsilon_1 \quad (3)$$

By replacing $(X_0 - X_1)$ with X , we get:¹⁴

$$u_0 - u_1 = X\beta + \gamma WTP + \varepsilon_0 - \varepsilon_1 \quad (4)$$

Taking the expectation of both sides of equation (4) we get:

$$E[u_0 - u_1] = E[X] \cdot E[\beta] + E[\gamma] \cdot E[WTP] + E[\varepsilon_0 - \varepsilon_1] \quad (5)$$

Further simplification will result:

$$E[u_0 - u_1] = E[X] \cdot \beta + \gamma \cdot E[WTP] + E[\varepsilon_0 - \varepsilon_1] \quad (6)$$

In answering the CV question, the respondent maintains the same level of utility by giving up an amount of money equal to WTP and acquires the improved service. By doing this the household maintains its original utility level, therefore, u_0 and u_1 are equal. Thus:

$$0 = E[X] \cdot \beta + \gamma \cdot E[WTP] \quad (7)$$

$$E[WTP] = - (E[X] \cdot \beta) / (\gamma) \quad (8)$$

Equation (8) can be used to estimate mean WTP for the study sample.

¹² X should be treated as a vector of commodities and β as a vector of corresponding regression coefficients.

¹³ Here we assume that household actually behaves according to the answer.

¹⁴ X will account for the difference in the consumption of the composite commodity due to the decision to purchase improved water services.

In a closed-ended CV study, households are provided with a set of bids (bids are randomly assigned among the survey participants) and asked whether the household is willing to pay the given bid amount for the improved WSS, in the form of increased water bills. Answers to this question come in the form of "yes" or "no." The dependent variable for the econometric model is formed by assigning 1 for "yes" and 0 for "no" answers. Then a probit regression model is estimated incorporating a set of relevant independent variables and the bid values. Equation (8) is used to calculate the mean WTP. First, regression coefficients in the estimated probit model should be multiplied by the mean values of the corresponding x variable then summed up.¹⁵ After summing up the resultant value should be divided by the coefficient of the bid variable. Finally, this result should be multiplied by -1 to obtain mean WTP. The same procedure can be used to calculate WTP for each household. Instead of the mean values of x variables, actual values of them for the household should be used to get the overall intercept in calculating WTP for a household.

¹⁵ If the regression equation includes an intercept that also should be added to this sum.

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