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Households' Willingness to Pay for Improved Tap Water Services in Karachi, Pakistan

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1. INTRODUCTION

Access to safe water is a basic need for human survival and health. Water is one of the most important commodities for households, who use it for drinking and many other important household activities including cooking a meal, washing dishes, bathing, laundry, cleaning, and watering the home gardens. Households need safe water and its availability on regular basis. Irregular and uncertain access to safe water affects not only these activities directly but also households' health and workforce productivity indirectly. Thus, households give great importance to water, its quality and regular supply.

Karachi is the most populated city of Pakistan with population over 13 million in 2010 and is among top ten mega-cities of the world [Pakistan (2010)]. Insufficient access to safe water is one of the major challenges facing households in Karachi city due to its burgeoning population and increasing demand for water. According to City District Government Karachi (2007), only 60 percent of the households in Karachi are connected to piped water supply, provided by the city government through the Karachi Water and Sewerage Board (KWSB). Furthermore, water is delivered on schedule for only four hours per day, which is often irregular and uncertain in many locations due to poor infrastructure and inadequate maintenance of piped water supply system. Given the water shortage in the city, the residents buy water from private water tankers.

In addition to inadequate quantity of water, the quality of water is also a big issue. According to Pakistan Council of Research in Water Resources [PCRWR (2007)], water in Karachi is unsafe to drink as it is mostly contaminated with Coliforms and E. coli. PCRWR (2007) collected water samples from major parts of Karachi and found that 93 percent of the water samples were unsafe as they were contaminated with Coliforms and E. coli (86 percent) and had excessive level of mineral and elements (7 percent). Water provided to households in Karachi is unsafe to drink because it is not properly treated and is contaminated as a result of the leakage of sewage and industrial waste through

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damaged pipes. For drinking purpose, some households boil water, filter water, or purchase bottled water. Due to unawareness and other reasons, many households are not able to adopt these coping activities, and continue to face health issues caused by unsafe water. PCRWR (2007) reports that every fifth citizen in Pakistan suffers from illness caused by unsafe water. Thus, there is a need to address the issue of both quantity and quality of water.

There are a wide range of factors that contribute to water supply inefficiencies and unsafe water in Karachi, but one of the most significant is the poor infrastructure in piped water supply system. The existing water supply network in Karachi is over 100 years old and has become outdated and defective. According to a study conducted by Asian Development Bank [ADB (2004)], capital expenditure per connection in Karachi is only US$7 per year, which is one of the lowest in the region. It is US$78 in Delhi, US$140 in Dhaka, and the average expenditure in major Asian cities is US$88 (Table 1). Furthermore, only 0.3 percent of the water connections are metered in Karachi and the remaining connections (99.7 percent) are charged with flat rate tariff based on floor areas of domestic properties, resulting in unchecked high consumption of water by the connected households. The main reason of low expenditure on water supply infrastructure is insufficient revenue generated from collection of water bills, which does not even cover operations and maintenance costs. The estimated average tariff per cubic meter of water in Karachi is only US$0.07, which is one of the lowest in the region (Table 1). The estimated average tariff rate is computed as total revenue from tariff divided by total consumption of water. Thus, the reasons for a low tariff rate in Karachi include flat tariff rate based on floor area, low collection efficiency (54 percent), and unchecked high consumption of water by the connected households. Given the poor infrastructure in the piped water supply system, Karachi needs more funds for improving tap water supply infrastructure as well as for its operation and maintenance in order to improve the water efficiencies and water quality in the city.

Table 1

Performance Indicators of Water Services in Major Cities of South Asia

	Colombo	Delhi	Dhaka	Jakarta	Karachi	Kathmandu
Per capita production per day (m^3)	0.48	0.3	0.22	0.27	0.34	0.11
Water supply coverage (% of people)	69	69	72	51	58	83
24–hour availability (% of people)	60	1	0	92	0	0
Per capita consumption per day (liters)	119	110	115	77	197	68
Average tariff per m^3 (US$)	0.22	0.07	0.06	0.29	0.07	0.09
Revenue collection efficiency (%)	95	70	82	98	54	70
Capital expenditure per connection (US$)	8	78	140	47	7	17

Source: Asian Development Bank (2004).

Considering the importance of access to safe water, the government has been making efforts to improve the tap water services in Karachi. In July 2013, KWSB has launched a water supply project, named K-IV Project, in collaboration with the China International Water and Electric Corporation (CWE) with aims to augment the water supply and to improve the quality of water in Karachi in near future. Currently, the government is providing a subsidy on water services with flat rate tariff based on floor areas of domestic properties in Karachi. According to a study by Briscoe, *et al*. (2005) the subsidised tariff benefits more to those living in higher income areas rather than the poor. As improvements in the tap water services will result in higher cost of the service, the cost recovery is the key requirement for providing the improved water services that can be sustained over time.

As water is a basic need, appropriate pricing policy must take into account how much consumers place value and are prepared to pay for improvement in the tap water services, which varies depending on household income and other factors. Thus, there is a need to examine the demand and willingness to pay for improved tap water services by different income classes of households, which will help the policy makers in designing an appropriate water tariff structure for generating sufficient revenue to cover the cost of improved water services.

Estimation of willingness to pay also provides the information on the monetary value of the benefits from improving the access to safe of water. This information is useful for policy makers in making investment decisions based on benefits and costs of improvement of water services. Furthermore, in developing countries, policy makers generally do not give its due consideration to investment for the provision of improved water supply schemes as they assume that the public is unwilling to pay a higher tariff and the cost of the project will fall onto the already heavily burdened national exchequer unless a donor or lending agency proposes to fund the service provision. Failure to designing proper pricing policy for water services in the past has resulted in under-investment, poor maintenance, slow progress in extending coverage, and wastage of water. Therefore, estimation of the willingness to pay will be useful for policy makers in making efficient investment decisions as well as in designing pricing policies for sustainable management and provision of water services that will improve the welfare of the society.

The objective of this study is to evaluate the households' willingness to pay (WTP) for improved tap water services by different income classes of households in Karachi. This study uses contingent valuation method (CVM) and uses the single and double bound dichotomous choice elicitation techniques. WTP is estimated by probit model, interval data model and bivariate probit model using survey data from sampled households connected to tap water services in Karachi.

The remainder of this paper is organised as follows. The next section presents a brief literature review. Section 3 specifies the model of this study. Section 4 presents the estimation methods. Section 5 describes study area, sampling and data collection methods. Section 6 presents the empirical results of the study. Finally, Section 6 draws conclusion and offers their policy implication.

2. LITERATURE REVIEW

CVM became popular for valuation of infrastructure projects in developing countries after Whittington (1987), who specifically used CVM as a tool for helping to evaluate water supply projects. According to Birol, *et al*. (2006), more than 5000 CVM studies have been conducted in over 100 countries to examine water related issues and other resource. Cities for which such studies have been conducted include Dhaka [Chowdhry (1999)], Calcutta [Guha (2007)], central Tanzania [Kaliba, *et al*. (2002)], Colombo [Jones, *et al*. (2006)], Khulna [Gunatilake and Tachiiri (2012)], and cities in Pakistan including Abbottabad [Haq, *et al*. (2007)], Hyderabad [Sattar and Ahmad (2007)], Peshawar [Khan (2010)], and rural Punjab [Altaf, *et al*. (1992)]. This section presents the review of selected relevant studies.

Bogale and Urgessa (2012) estimated willingness to pay of rural households for improved water service in Haramaya district, Ethiopia. The study administered double bounded dichotomous choice method, and data were analysed using the bivariate probit model. It was revealed that households expressed a mean WTP of 27.30 cents per 20 liters. Main determinants of WTP were household income, education, sex, time spent to fetch water, water treatment practice, quality of water and expenditure on water, and age of the respondent.

The factors that explained citizens' willingness to pay in Ado Ekiti [Olajuyigbe and Fasakin (2010)] were main source of domestic water used by household, access to improved source of water, distance from main source to house, average time spent to fetch water, adequacy of supply, quantity of water used per person per day, quantity of water purchased per day, incidence of water borne diseases, performance of water providing institution and average amount spent on water during the dry season. There are several other studies that have been conducted all around the world that have given similar results.

Banda, *et al*. (2007) used a tobit model to analyse factors affecting the probability that a household is willing to pay for both improved quantity and quality of water in rural area of South Africa. The study found that households' income, availability of water, households' access to a tap and water per capital, monthly water consumption were significant determinants of WTP.

Lema and Beyene (2012) studied WTP for improved water services in Goro-Gutu district of Eastern Ethiopia. The study uses both binary and ordered probit models to examine the determinants of willingness to pay. The estimated mean and median willingness to pay was found to be Birr 6.83 and 5.87 per household per month.

A study by the World Bank shows that contingent valuation correctly predicted 91 percent of the decisions of investments in piped water system [Cropper and Alberini (1998)]. Wattage, *et al*. (2000)] argue persuasively that contingent valuation (CV) is the most all-encompassing way to measure the benefits of water quality improvement investments.

Review of the previous studies show that there are a number of elicitation techniques and econometric models to estimate WTP. CVM is used for recovering the information about willingness to pay by direct questions. There are different types of elicitation techniques in CVM to elicit WTP information. The closed-ended dichotomous choice techniques have become credible approach in CVM studies [Haab and McConnel (2002)]. Therefore, this study uses dichotomous choice closed-ended questions.

With dichotomous choice closed-ended questions, most commonly used techniques are single-bound and double-bound dichotomous choice questions. In single-bound dichotomous choice, respondent is asked only once about WTP and is expected to answer yes or no. In this case, WTP can be estimated by probit model. In the double-bound dichotomous choice, respondent is asked a follow-up question contingent upon the response to the initial question. Hanemann, Loomis, and Kanninen (1991) showed that a follow-up question significantly increases the statistical efficiency of willingness to pay estimates. In this case, WTP can be estimated by interval data model. However, the literature indicates that the respondent is likely to change or adjust the value of WTP when the second question is asked. To address this issue, bivariate probit model was used to estimate WTP. However, Haab and McConnell (2002) raises the concern that the researcher has to decide whether to rely on the WTP based on initial or follow-up response. Thus, with dichotomous choice closed-ended questions, most of the previous studies have used one of the following models: probit model, interval data model and bivariate probit model. For checking robustness of the results, the present study uses these three econometric approaches, namely, probit model, interval data model and bivariate probit model, to estimate the WTP for improved tap water services in Karachi.

3. MODEL

There are two broad categories of approaches to measure WTP: stated preference and revealed preference. Stated preference approaches, such as CVM, use survey techniques to elicit willingness to pay and allow the researcher to evaluate the benefits of specific changes or improvement in a service. Revealed preference approaches, such hedonic pricing models and averting expenditure methods, are based on actual observable choices to estimate the value of improvement in service, directly inferred from those choices [Tietenberg and Lewis (2012)]. This study uses contingent valuation method of stated preference approach to measure the WTP for improved tap water services with continuous supply of good quality water that is potable without boiling or any other treatment. This section presents the economic theory of WTP in the context of CVM [Haab and McConnel (2002)], and specifies econometric model of WTP function.

3.1. Economic Theory of WTP

Consider a household who maximises a utility function subject to a budget constraint, and the household's indirect utility function is as follows:

$$V = V(p, q, m) \quad \ldots \quad \ldots \quad \ldots \quad \ldots \quad \ldots \quad \ldots \quad \ldots \quad (1)$$

where p is the vector of the prices of the market commodities, q is the status of tap water services acquired by the household, and m is the household income.

Denote q_0 as the existing status of tap water services received by the household, and q_1 as the improved status of tap water services. In this study, improved status is represented by a scenario such that the household will receive continuous water supply with sufficient pressure, and the water will be of good quality and potable without boiling or any other treatment. The value of the change to household in monetary terms is represented by the Hicksian measure, the compensating variation C which satisfies:

$$V(p, q_1, m - C) = V(p, q_0, m) \quad \ldots \quad \ldots \quad \ldots \quad \ldots \quad \ldots \quad (2)$$

As the change in q from q_0 to q_1 is an improvement in the tap water services and raises the household's utility level, C would be positive. In this case, C measures the household's willingness to pay (WTP):

$$V(p, q_1, m - \text{WTP}) = V(p, q_0, m) \quad \ldots \quad \ldots \quad \ldots \quad \ldots \quad \ldots \quad (3)$$

WTP is the maximum amount of money the household will pay in exchange for the improvement in the tap water services from q_0 to q_1. Solving Equation (3) for WTP provides WTP function:

$$\mathrm{WTP} = \mathrm{WTP}(p, m, q_0, q_1) \quad \ldots \quad \ldots \quad \ldots \quad \ldots \quad \ldots \quad \ldots \quad (4)$$

The WTP function in Equation (4) indicates that WTP depends on the prices of the market commodities (p), the household income (m), the existing status of tap water services acquired by the household (q_0), and the improved status of tap water services (q_1).

3.2. Econometric Specification of WTP Function

For estimating WTP function using cross sectional household level data, we need to specify econometric model. We assume that the all households face the same prices of the market commodities (p) and the same improved status of tap water services (q_1). Thus, WTP varies across households depending on the household income (m) and the existing status of tap water services (q_0). Furthermore, household's WTP may also be affected by other household characteristics. Thus, the econometric model for WTP is specified as:

$$WTP = e^{x\beta+\varepsilon} \quad \ldots \quad \ldots \quad \ldots \quad \ldots \quad \ldots \quad \ldots \quad \ldots \quad (5)$$

where x is the vector of explanatory variables, β is the vector of unknown parameters, and ε is the error term representing the unobserved other factors. In Equation (5), the exponential WTP function ensures that the predicted WTP is positive and thus does not provide any negative predicted values of WTP. This property is important as WTP is the maximum amount of money the household will pay in exchange for the improvement in the tap water services. For estimating WTP function, Equation (5) can be re-written as:

$$\ln(WTP) = x\beta + \varepsilon \quad \ldots \quad \ldots \quad \ldots \quad \ldots \quad \ldots \quad \ldots \quad (6)$$

In this study, the explanatory variables for the above econometric model include dummy variables for different income classes, number of hours of water per week received by the household, household's rating for water quality, residence type (single or double storied house), and block of study area. Further details of these variables are presented in the results.

4. ESTIMATION METHODS

The purpose of contingent valuation method is to estimate individual WTP for changes in the quality of goods or services. This section describes methods for estimating the WTP function specified above. Estimation method depends on how the information on WTP is elicited. This section describes elicitation techniques and methods for estimating the WTP function used in this study. We follow the estimation methods given in [Haab and McConnel (2002) and Lopez-Feldman (2012)].

4.1. WTP Elicitation Techniques

CVM is used for recovering the information about willingness to pay by direct questions. There are different types of elicitation techniques in CVM to elicit WTP information. These include: open-ended question, bidding games, payment cards, closed-ended single-bound dichotomous choice question, and closed-ended double-bound dichotomous choice questions. Among these, the closed-ended dichotomous choice techniques have become credible approach in CVM studies [Haab and McConnel (2002)]. Therefore, this study uses both single-bound and double-bound dichotomous choice closed-ended questions.

In the single-bound dichotomous choice question format, the respondent is asked whether he or she would be willing to pay a certain monthly charge for improved tap water services. In this format, each individual is offered a single bid value and is expected to answer yes or no. The individual would answer yes if his/her WTP is greater than the offered bid amount, and would answer no if his/her WTP is less than the offered bid amount.

In the double-bound dichotomous choice, the respondent is followed up by a second question about willingness to pay contingent upon the response of the first question. The second question would be asked with a higher bid amount if the answer to the first question is yes, or with a lower bid amount if the answer to the first question is no. The respondent is expected to answer yes or no to the second question.

4.2. Estimation Methods with Single-Bound Dichotomous Choice

WTP function in Equation (6) for an individual i can be written as:

$$\ln(\mathrm{WTP}_i) = x_i\beta + \varepsilon_i \qquad \ldots \quad \ldots \quad \ldots \quad \ldots \quad \ldots \quad \ldots \qquad (7)$$

In the single-bound dichotomous choice question format, the respondent is asked whether he or she would be willing to pay a certain monthly charge for improved tap water services. In this format, each individual is offered a single bid value and is expected to answer yes or no. The individual would answer yes if his/her WTP is greater than the offered bid amount, and would answer no if his/her WTP is less than the offered bid amount.

$\mathrm{WTP}_i \geq \mathrm{bid}_i$ if the answer is yes
$\mathrm{WTP}_i < \mathrm{bid}_i$ if the answer is no

Denote $y_i = 1$ if the answer is yes, and $y_i = 0$ if the answer is no. The probability of $y_i = 1$ is a function of the explanatory variables and can be written as:

$$\Pr(y_i = 1 | x_i) = \Pr(\mathrm{WTP}_i > \mathrm{bid}_i) \qquad \ldots \quad \ldots \quad \ldots \quad \ldots \qquad (8)$$

$$\Pr(y_i = 1 | x_i) = \Pr(\ln(\mathrm{WTP}_i) > \ln(\mathrm{bid}_i)) \qquad \ldots \quad \ldots \quad \ldots \qquad (9)$$

Plugging Equation (7) into Equation (9) yields:

$$\Pr(y_i = 1 | x_i) = \Pr(x_i\beta + \varepsilon_i > \ln(\mathrm{bid}_i)) \qquad \ldots \quad \ldots \quad \ldots \quad \ldots \qquad (10)$$

$$\Pr(y_i = 1 | x_i) = \Pr(\varepsilon_i > \ln(\mathrm{bid}_i) - x_i\beta) \qquad \ldots \quad \ldots \quad \ldots \quad \ldots \qquad (11)$$

For probit model, it is assumed that the error term ε_i has a normal distribution $N(0, \sigma^2)$. In this case, Equation (10) can be written as:

$$\Pr(y_i = 1 \mid x_i) = \Phi\left(\frac{x_i\beta}{\sigma} - \frac{\ln(\text{bid}_i)}{\sigma}\right) \quad \ldots \quad \ldots \quad \ldots \quad \ldots \quad (12)$$

where Φ (.) denotes the standard cumulative normal distribution function. There are two approaches to estimate this model. The first one is to use Equation (12) and apply maximum likelihood estimation methods to estimate β and σ. The other approach, which we use in this study, is to directly estimate the probit model with x_i and ln(bid$_i$) as explanatory variables, which can be estimated in STATA or any other software. In this case, we obtain the estimates of β/σ and $-1/\sigma$ after estimating the probit model (see Equation (12)). For the results of probit model, denote $\hat{\beta}/\hat{\sigma}$ as the vector of coefficient estimates associated to each one of the explanatory variables and $-1/\hat{\sigma}$ as the coefficient estimate on ln(bid$_i$)). The expected value of WTP can be computed for individuals with given values of explanatory variables $\tilde{x}$ as:

$$E(WTP|\tilde{x}) = e^{\tilde{x}\hat{\beta}+0.5\hat{\sigma}^2} = e^{-\frac{\tilde{x}\hat{\beta}/\hat{\sigma}}{-1/\hat{\sigma}}+0.5\hat{\sigma}^2} \quad \ldots \quad \ldots \quad \ldots \quad \ldots \quad (13)$$

4.3. Estimation Methods with Double-Bound Dichotomous Choice

In the single-bound dichotomous choice question format, the respondent is offered a single bid value and is expected to answer yes or no only once. In the double-bound dichotomous choice, the respondent is followed up by a second question about willingness to pay contingent upon the response of the first question. Denote bid$_1$ as the bid amount in the first question. The second question would be asked with a higher bid amount (bid$_{2(max)}$) if the answer to the first question is yes, or with a lower bid amount (bid$_{2(min)}$) if the answer to the first question is no. The respondent is expected to answer yes or no to the second question.

With double-bound dichotomous choice questions, WTP can be estimated either by the interval data model or by a bivariate probit model.

4.3.1. *Interval Data Model: Ordered Probit Model*

This section describes estimation method by the interval data model (also referred to as ordered probit model) with double-bound dichotomous choice questions format. Given the responses of two questions, the bounds on the WTP depend on the answers to the two questions:

(i)	WTP ≥ bid$_{2(max)}$	if the responses are yes and yes
(ii)	bid$_1$ < WTP ≤ bid$_{2(max)}$	if the responses are yes and no
(iii)	bid$_{2(min)}$ < WTP bid$_1$	if the responses are no and yes
(iv)	WTP < bid$_{2(min)}$	if the responses are no and no

The probability of each one of the possible response sets given above is given as follows:

(i) Yes and Yes

$$\Pr(y_{1i} = 1 \text{ and } y_{2i} = 1|x_i) = \Pr(WTP > \text{bid}_{2(\text{max})}) \quad \ldots \quad \ldots. \quad \ldots \quad (14)$$

Following the procedure described in Section 4.1, Equation (14) can be written as:

$$\Pr(y_{1i} = 1 \text{ and } y_{2i} = 1|x_i) = \phi\left(x_i \frac{\beta}{\sigma} - \frac{\ln(\text{bid}_{2(\max)})}{\sigma}\right) \quad \dots \quad \dots \quad \dots \quad (15)$$

(ii) Yes and No:

$$\Pr(y_{1i} = 1 \text{ and } y_{2i} = 0|x_i) = \Pr(\text{bid}_1 < WTP < \text{bid}_{2(\max)}) \quad \dots \quad \dots \quad (16)$$

$$\Pr(y_{1i} = 1 \text{ and } y_{2i} = 0|x_i) = \phi\left(x_i \frac{\beta}{\sigma} - \frac{\ln(\text{bid}_1)}{\sigma}\right) - \phi\left(x_i \frac{\beta}{\sigma} - \frac{\ln(\text{bid}_{2(\max)})}{\sigma}\right) \quad (17)$$

(iii) No and Yes:

$$\Pr(y_{1i} = 0 \text{ and } y_{2i} = 1|x_i) = \Pr(\text{bid}_{2(\min)} < WTP < \text{bid}_1) \quad \dots \quad \dots \quad (18)$$

$$\Pr(y_{1i} = 0 \text{ and } y_{2i} = 1|x_i) = \phi\left(x_i \frac{\beta}{\sigma} - \frac{\ln(\text{bid}_{2(\min)})}{\sigma}\right) - \phi\left(x_i \frac{\beta}{\sigma} - \frac{\ln(\text{bid}_1)}{\sigma}\right) \dots \quad (19)$$

(iv) No and No:

$$\Pr(y_{1i} = 0 \text{ and } y_{2i} = 0|x_i) = \Pr(WTP < \text{bid}_{2(\min)}) \quad \dots \quad \dots \quad \dots \quad (20)$$

$$\Pr(y_{1i} = 0 \text{ and } y_{2i} = 0|x_i) = 1 - \phi\left(x_i \frac{\beta}{\sigma} - \frac{\ln(\text{bid}_{2(\min)})}{\sigma}\right) \quad \dots \quad \dots \quad (21)$$

The parameters of the model β and σ can be estimated by maximum likelihood estimation method using the above probability functions given in Equations (15), (17), (19), and (21). In this study, the model is estimated using the "doubleb" command in STATA 11. Given the maximum likelihood estimates $\hat{\beta}$ and $\hat{\sigma}$, the expected value of WTP can be computed for individuals with given values of explanatory variables $\tilde{x}$ as:

$$E(WTP|\tilde{x}) = e^{\tilde{x}\hat{\beta} + 0.5\hat{\sigma}^2} \quad \dots \quad \dots \quad \dots \quad \dots \quad \dots \quad \dots \quad (22)$$

4.3.2. ***Bivariate Probit Model***

Like the interval data model, the bivariate probit model is another method for two-response surveys with double-bound dichotomous choice questions. The bivariate probit model was initially introduced by Cameron and Quiggin (1994). It was argued that when the individuals are asked two questions, the respondents may reconsider about their WTP and the distribution of WTP may change from initial question to the follow-up question. The bivariate probit model allows for the possibility of different distributions of WTP across the initial and follow-up question while the interval data model assumes the same distribution of WTP during initial question and the follow-up question.

In the bivariate probit model, the two dichotomous choice responses are simultaneously modeled as single-bounded, i.e. two correlated WTP equations with jointly distributed normal error terms. The bivariate probit model relaxes the restrictive assumptions of the interval data model and solves the problem of potential bias caused by these assumptions. We use probit because it allows for non-zero correlation, while the logistic distribution does not. In the bivariate probit model, the WTP functions for an individual *i* can be written as:

$$\ln(\text{WTP}_{1i}) = x_i\beta_1 + \varepsilon_{1i} \quad \dots \quad \dots \quad \dots \quad \dots \quad \dots \quad \dots \quad (23)$$

$$\ln(\mathrm{WTP}_{2i}) = x_i\beta_2 + \varepsilon_{2i} \quad \ldots \quad \ldots \quad \ldots \quad \ldots \quad \ldots \quad \ldots \quad (24)$$

It is assumed that the error terms, ε_1 and ε_2, are normally distributed with mean zero and respective variances σ_1 and σ_2, and have a bivariate normal distribution with correlation coefficient ρ. The bivariate probit model was estimated by the maximum likelihood estimation technique using "biprobit" command in STATA 11.

As the distributions of WTP are likely to be different across the initial question and follow-up question, the researcher has to decide which distribution to use for estimating WTP even after estimating the both distributions in the bivariate probit model. As used in most of the CVM studies, we use initial distribution of WTP as given in Equation (23). After estimating the bivarite probit model, the expected value of WTP can be computed for individuals with given values of explanatory variables $\tilde{x}$ as:

$$E(WTP|\tilde{x}) = e^{\tilde{x}\hat{\beta}_1 + 0.5\hat{\sigma}_1{}^2} = e^{-\frac{\tilde{x}\hat{\beta}_1/\hat{\sigma}_1}{-1/\hat{\sigma}_1} + 0.5\hat{\sigma}_1{}^2} \quad \ldots \quad \ldots \quad \ldots \quad \ldots \quad (25)$$

5. DATA

5.1. Study Area and Sampling Strategy

Karachi lies on Pakistan's southern coast, on the Arabian Sea just northwest of the Indus River Delta. It is also the principal seaport and financial center of Pakistan. The city consists of 18 towns, which are governed by elected municipal administrations responsible for infrastructure planning, development facilitation, and municipal services which include water, sanitation, solid waste, repairing roads, parks, street lights, and traffic engineering. The KWSB is a public sector organisation responsible for production, transmission and distribution of water services to the citizen of Karachi.

From 18 towns of Karachi, Gulshan-e-Iqbal town was selected for primary data collection keeping in view the geographical expanse of the city and budget limitation for sample size (see Figure 1 for a map). Gulshan-e-Iqbal town has a population of over a million people. Gulshan-e-Iqbal is selected because the town is a major residential area in the city and is known for its income and ethnic diversity. Two neighborhoods (Block 4 and 7) of Gulshan-e-Iqbal were selected for sampling. Both the towns are similar in terms of size (Figure 2); however bill collection in Block 4 is lower than in Block 7 (Table 2). Choosing two locations, which are adjacent but with unique neighborhood characteristics, will allow us to control for unobserved location specific heterogeneity for analysing the determinants of WTP.

A total sample of 400 households was selected using a random sampling method. Starting at a certain location, surveyors were asked to knock at every fifteenth house on their left, alternating between left and right at every turn. In case of non-response, they were asked to knock on the next door. As some of the respondent did not answer to question on income, the final dataset for the analysis included 373 observations. Out of the 2879 households connected to the piped water services, this sample size would be representative at 5 percent margin of error.

Fig. 1. Map of Gulshan-e-Iqbal Town in Karachi

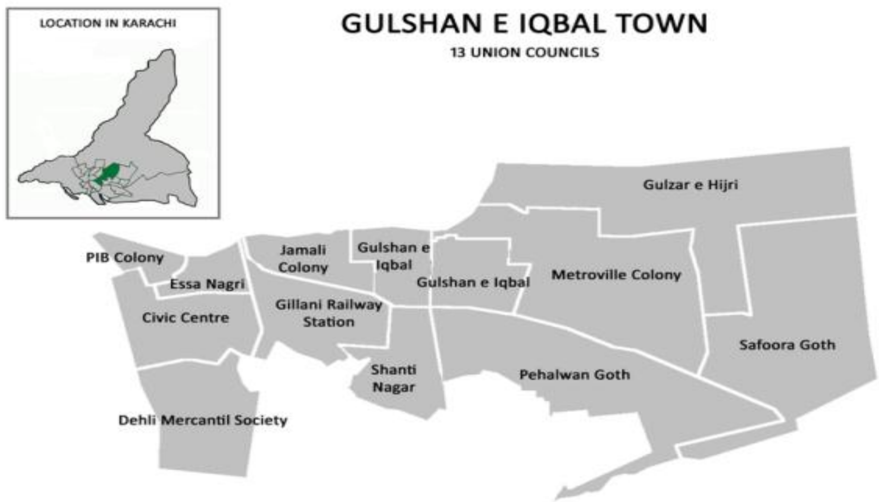

Fig. 2. Map of Block 4 and 7, Gulshan-e-Iqbal, Karachi

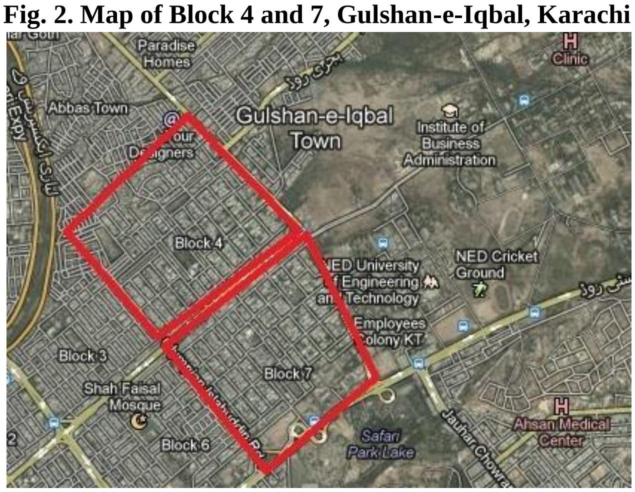

Table 2

Block-wise Revenue Collection

	Total Number of Bills	Total Receipt (Rs/Month)
Block 7 in Gulshan-e-Iqbal town, Karachi	2201	7712460
Block 4 in Gulshan-e-Iqbal town, Karachi	2678	6473321

Source: KWSB (2012).

5.2. Questionnaire and Data Collection Method

While designing the questionnaire an attempt was made to minimise strategic, hypothetical and compliance biases which may arise from CV survey. To minimise strategic bias, an introductory statement was read to all respondents before interviewing began to clarify the purpose of the survey. Hypothetical bias is unlikely to occur since the service in question is familiar to all respondents of the town. In order to reduce compliance bias, the survey was carefully designed, and the interviewers were trained. The questionnaire includes the following sections: existing water supply situation, incidence of water related diseases, CV questions on willingness to pay, and household characteristics and income.

5.2.1. *Contingent Scenario*

As given in the questionnaire, for eliciting the WTP, the respondents were informed about the contingent scenario. Improved status of tap water services is represented by a scenario such that the household will receive continuous water supply with sufficient pressure, and the water will be of good quality and potable without boiling or any other treatment.

5.2.2. *Payment Vehicle and Bid Values*

In the present study, we have chosen monthly water bill as payment vehicle for WTP. Households were asked whether they are willing to pay a certain monthly charge for improved water supply services. The questionnaire uses double-bounded dichotomous choice questions, where respondents were followed up by a second question contingent upon the response of the initial bid. To obtain a preliminary guess about the WTP distribution we conducted a pilot study to determine bid values. Very low bids elicited all "Yes" responses and very high bids elicited all "No" responses. The current bid structure gave a varied combination of the two. Table 3 presents the initial bid values and bid values in the follow-up question. The level of initial bid was randomly assigned to each household.

Table 3

Bidding Structure

Bid	Notation	Bid Values (Rs/Month)				
Initial bid	bid_1	500	1000	2000	4000	5000
Follow-up bid if response to initial bid is yes	$bid_{2(max)}$	1000	2000	3000	5000	7000
Follow-up bid if response to initial bid is no	$bid_{2(min)}$	250	500	1500	2500	3000

For estimating the interval data model and bivariate probit model, the survey was conducted to collect data for double-bounded dichotomous choice questions (two questions) using initial bid and a follow-up bid. For estimating the probit model with single-bound dichotomous choice, the data on responses to the initial bid were used for the analysis.

5.2.3. *Data Collection Method*

A household survey, as opposed to telephone interviews, was conducted keeping in view the suggestions from the NOAA panel report [Arrow, *et al*. (1993)]. Data were collected by surveying households and conducting in-person interviews using a structured questionnaire. The survey was conducted on weekends and public holidays in December 2012 so that household heads could be found at home. Eleven interviewers were trained for data collection. Each interviewer conducted an average of 15 interviews a day. Fifty percent of the questionnaires were answered by household heads. However, it was made sure that all respondents were above the age of 18 years.

6. EMPIRICAL RESULTS

This section presents the empirical findings of our contingent valuation survey, and discusses the results obtained. We present descriptive statistics, regression results and WTP estimates.

6.1. Descriptive Statistics

The households were given the list of selected six social services (health, road, electricity, school, telephone and water) and were asked to rank in accordance with their priority of need: 1 being the most important, 6 being the least important. Survey results show that 37 percent of the respondents rated water as the most important public utility (Figure 3). Each utility was assigned a score according to the ranking given by the respondents. According to the scores, these six services were ranked in the following order: health, water, school, electricity, road, and telephone. Thus, overall, water is ranked second after health, indicating that water is an essential need of the public.

Inadequate and unreliable water supply has made consumer to move towards more reliable alternatives. In order to meet the daily water needs, the households need to use alternative water sources, such as mineral water, water tankers and boring wells, in addition to treat water due to unreliability of its quality. The Venn diagram in Figure 4 shows the percentage of people using water tankers, boring wells and mineral water. Eighty percent of the households run motors to pump water from the lines or from wells (for groundwater). Eleven percent of the respondents have a well installed in the residence. On average, respondents also run their electric motors for 3 hours per day. Twenty three percent of the households use water tankers to meet their water requirements while the 50 percent of households drink mineral water or canned water. Only 10 percent of the households did not use any of these alternate water sources.

Fig. 3. Ranking of Water by Households

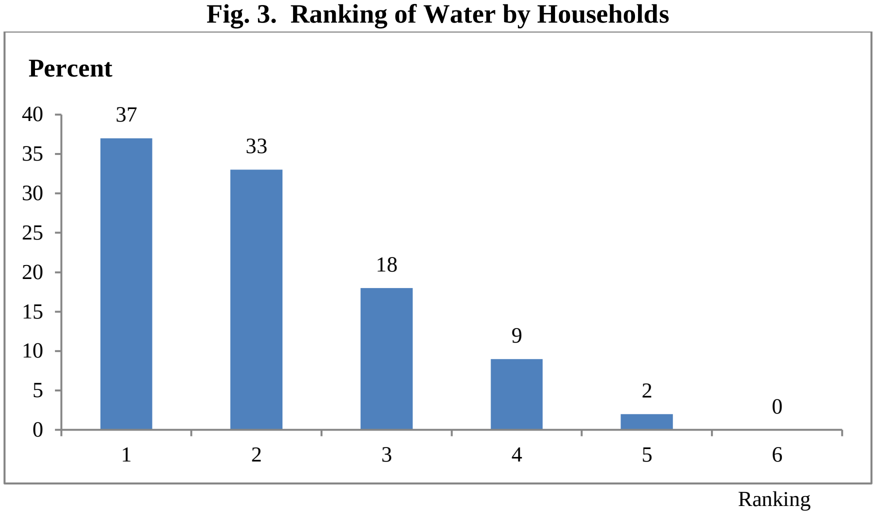

Fig. 4. Coping Behavior

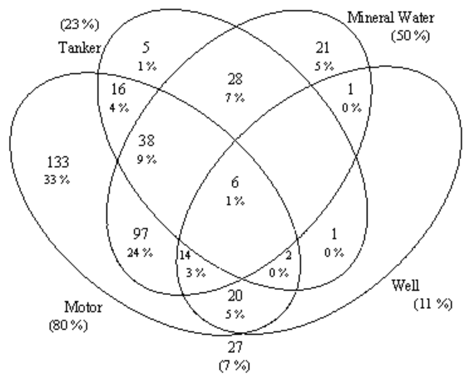

Table 4 presents the summary statistics of the variables used in the model. Fifty four percent of the households responded yes to initial bid for WTP. In the follow-up bid, 43 percent of households responded yes. Four income classes were defined based on household's monthly income in the following ranges: less than Rs 20,000; Rs 20,000 – 50,000; Rs 50,001 – 100,000; and greater than Rs 100,000, designated as income class 1, 2, 3 and 4, respectively. The proportion of households in different income classes is reported in Table 4. Eight percent of households were in income class 1 while 38 percent, 32 percent and 22 percent of households were in income class 2, 3 and 4, respectively. On average, the households receive 27 hours of water supply in a week. Households were asked to rate their satisfaction from current piped water supply on a scale of 1 to 5 (1 being the lowest). The results show the households were only moderately satisfied with current water supply.

Table 4

Summary Statistics

Variable	Definition	Mean	Std. Dev.	Min	Max
Response to initial bid	yes=1; no=0	0.54	0.50	0	1
Response to follow-up bid	yes=1; no=0	0.43	0.50	0	1
Income class 1	1 if monthly household income < Rs. 20,000; 0 otherwise	0.08	0.27	0	1
Income class 2	1 if monthly household income in the range of Rs. 20,000 – 50,000; 0 otherwise	0.38	0.48	0	1
Income class 3	1 if monthly household income in the range of Rs. 50,001 – 100,000; 0 otherwise	0.32	0.47	0	1
Income class 4	1 if monthly household income > Rs. 100,000; 0 otherwise	0.22	0.42	0	1
Hours of water	Hours of water in a week	26.7	28.7	3	168
Water quality satisfaction	Household's rating for water quality (1 to 5)	2.58	1.17	1	5
Residence type	1 if single storied; 2 if double storied	1.73	0.44	1	2
Block	1 if Block 7; 0 if Block 4	0.34	0.47	0	1

6.2. Regression Results

To estimate WTP, three models are estimated: probit model, interval data model and bivariate probit model, as explained in Section 4. For examining the determinants of WTP, these models include the following explanatory variables: dummy variables for different income classes, number of hours of water per week received by the household, household's rating for water quality, residence type (single or double storied house), and block of study area (Block 4 or Block 7 of Gulshan-e-Iqbal town in Karachi). Given the four income classes, three dummy variables were created for all income classes except for the lowest income class, which is represented by the intercept (constant) of the regression model.

Table 5 presents the regression results of the three models. The results of all models show that dummy variables of income classes are statistically significant at 1 percent or 5 percent level of significance and the sign is positive as expected. This result is consistent with economic theory, which states that demand for a particular commodity depends on income. Results indicate that households with higher income are willing to pay more for an improved tap water service than those with lower income. Availability of water in terms of number of hours of water per week received is statistically significant.

Table 5

Regression Results

			Bivariate Probit Model	
Variables	Probit Model	Interval Data Model	Initial Response	Follow-up Response
Constant	5.408***	6.223***	5.545***	0.813***
	(6.850)	(17.04)	(7.017)	(2.608)
Income class 2	0.589**	0.786***	0.630**	0.813***
	(1.977)	(2.851)	(2.096)	(2.608)
Income class 3	0.875***	1.078***	0.909***	1.079***
	(2.880)	(3.831)	(2.956)	(3.414)
Income class 4	1.573***	1.776***	1.664***	1.631***
	(4.838)	(5.910)	(5.019)	(4.908)
Hours of water	–0.00474*	–0.00590**	–0.00504*	–0.00572**
	(–1.839)	(–2.515)	(–1.922)	(–2.298)
Water quality	–0.136**	–0.113**	–0.129*	–0.0802
Satisfaction	(–2.058)	(–1.985)	(–1.950)	(–1.328)
Residence type	0.224	0.344**	0.237	0.361**
	(1.336)	(2.351)	(1.408)	(2.293)
Block	0.0310	0.101	0.0467	0.116
	(0.188)	(0.712)	(0.282)	(0.773)
$\ln(bid_1)$	–0.808***	–	–0.836***	–
	(–8.696)		(–8.834)	
$\ln(bid_2)$	–	–	–	–0.597***
				(–5.266)
Observations	373	373	373	373

z-statistics in parentheses
*** p<0.01, ** p<0.05, * p<0.1

Results show that the household who receive more hours of water are willing to pay relatively less amount. Satisfaction of water quality perceived by households is also statistically significant. Results show that the household who are relatively less satisfied with the existing water quality are willing to pay relatively more amount. Residence type is significant in interval data model. Its positive sign indicates that the households with double-storied house are willing to pay more as compared to those with single-storied house. Regression results show that the natural log of bid amount is statistically significant at 1 percent level of significance and its sign is negative. This result is consistent with the economic theory. The probability of yes-responses decreases as the bid amount increases.

6.3. Average WTP for Improved Tap Water Services

The average WTP estimates based on results of three models are presented in Table 6. The table presents the average WTP for improved tap water services for each of the four income classes and the overall average for all households. The results show that the average WTP is between Rs 604 – 734 per month by households whose income is less Rs 20,000 per month. The average WTP increases as the income level increases. Households in income class 2 (Rs 20,000 – 50,000) are willing to pay between Rs 1,325 – 1,534 per month. Households in highest income class (with income greater than Rs 100,000) are willing to pay up to in the range of Rs 3,567 – 5,277 per month. The overall average WTP from all income classes is in the range Rs 1,922 – 2,126 per month. This amount is almost three times higher than the current average bill paid (Rs 703 per month).

Table 6

Average WTP in Rupees per Month for Different Income Groups

Income Group (Income in Rs/Month)	Probit Model	Interval Data Model	Bivariate Probit Model
Less than Rs 20,000	734	604	722
Rs 20,000 – 50,000	1,520	1325	1534
Rs 50,001 – 100,000	2,165	1774	2,141
Greater than Rs 100,000	5,140	3567	5,277
Overall Average	2,116	1,922	2,126

7. CONCLUSIONS AND POLICY IMPLICATIONS

This study uses a contingent valuation method to estimate the average WTP for improved tap water services and to examine the determinants of WTP using single and double bound dichotomous choice elicitation questions. Three models, probit model, interval data model and bivariate probit model, are estimated using household level data from Block 4 and Block 7 of Gulshan-e-Iqbal Town in Karachi. The results show that the overall average WTP by all households is in the range of Rs 1,922 – 2,126 per month whereas the current average bill paid is Rs 703 per month. These results show that the households are willing to pay much more than what they currently pay for a safe and regular water supply service.

A high WTP clearly indicates that there is a great demand for improved water services, and delivery institutions responsible for water supply should come up with projects that ensure a reliable and regular water supply. The result of the study shows that the demand for improved water services is significantly related to the income of the household. This study shows that a significant increase in water price is economically feasible as long as the poor households are properly subsidised.

The present study has focused on the demand side, studying about situation and attitude in water use, socio-economic condition, and people's willingness to pay for improved water supply service. However, this study does not deal with the institutional weakness of the KWSB or issues of bill collection and financial management. Increasing tariffs is thus a necessary but not a sufficient condition of making water delivery more efficient. The study was restricted to Blocks 4 and 7 of Gulshan-e-Iqbal town in Karachi. The findings of this study cannot be directly applied to other towns without first comparing other socioeconomic characteristics.

This study presents a strong case for investment in infrastructure projects that improve the water supply services in the city. The study presents strong evidence that cost recovery is possible by increasing tariffs for higher income households. A major implication of this study is imposition of cross subsidisation.

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Comments

This is a decent paper focusing on the demand for better tap water services in Karachi, which is Pakistan's most populated mega city. The paper aims to identify the revenue potential and have brought to light important insights from Karachi. It not only expresses the situation in numbers but also discusses the theoretical underpinning that makes the environmental valuation an important topic. The most important aspect of this paper is that it expresses the topic in a light manner and makes things easy to understand even for a person who has not worked in environmental valuation before.

Following are few comments which is expected to further improve the paper.

(1) First of all, there is slight repetition in the text that needs to be sorted out.
(2) Secondly, the paper sometimes gives the impression of a report rather than an academic paper, i.e., at times too many information is shared. Hence, information that is not of utter importance should be either deleted or put as annexure.
(3) The last paragraph at second page provides useful comparison related to water services for major Asian cities, however, I guess, if this can be presented in a Table, it will make comparison easy.
(4) At page 7, authors present that how they had structured the WTP questions. Though there are a number of ways in which such questions can be framed and the one used in this paper is one of them. However for those interested in the topic for future research I would like to mention that instead of the closed-ended double-bound dichotomous choice, the last of the three WTP questions, should be open-ended. The reason is that there would be people who would like to pay lower or higher amounts than those mentioned by the researcher so the only way to capture such bounds is to through an open-ended question at the end of double-bound dichotomous choice question. This will save us from losing any important information which we are deprived of with the closed-ended WTP question; that does not makes the maximum/minimum WTP obvious.
(5) Figure 1 is unnecessary and should be removed
(6) **Empirical Estimation:** This is the section which needs the highest level of attention.
(7) Above all, there should be a table presenting the descriptive statistics, so that the reader can get a feel of the data and it will make the inference easy
(8) For the income classes, there are overlaps in the class-ranges (e.g. less than Rs 20000; Rs 20,000-50,000; Rs 50,000- Rs 100,000); this will lead to double counting of cases that lie at the extremes of each interval. This needs to be corrected as if it happens to be as mentioned, this will render the results for income groups incorrect.

(9) Lastly, the authors leave some very important variables out of the model e.g. Household size, awareness, education which, the literature has identified, and has important bearing on the demand for improved water services. Hence such variable should be included in the model, if data permits.

At the end, I must congratulate the authors for such a decent effort and this paper offers a good contribution to literature.

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