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Toward Efficient, Equitable and Sustainable Municipal Water Supplies for Domestic Purposes in the West Bank: A Contingent Valuation Analysis

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Abstract: This paper is an empirical work dealing with municipal water services in the West Bank where the emphasis is put on the analysis of water management. Toward that end, the study used Contingent Valuation Method (CVM) to estimate the Total Economic Value (TEV) of domestic water uses. The application of this approach consists of the construction a hypothetical market. The dichotomous choice with follow-up format question was utilized in developing the CV questionnaire; this elicitation technique was used to model Willingness to Pay (WTP) utilizing Tobit econometric model, binary-Logit econometric model and Ordinary Least Squares (OLS). The estimated coefficients of the econometric models were utilized to determine the relationship between WTP and socioeconomic variables, Log-likelihood and adjusted coefficient of determination (adjusted R^2). Furthermore, the marginal impacts of the coefficients of Tobit model were used to measure the elasticities of the coefficients of the explanatory variables. The CVM was applied to a sample of 520 households in the Ramallah and Al-Bireh governorate including urban and rural areas, and refugee camps. The face to face (in-person) interview survey was adopted. To assess the performance of water pricing policy, a questionnaire survey was directed to the personnel staff of water institutions. This method was administrated to a sample of 117 employees in the water institutions. Descriptive statistics enhanced by non-parametric tests were used. The main findings of this study were measured the WTP with key socioeconomic variables suggested by economic theory and CV studies including income, age, gender, location, educational level, employment status, family size, water consumption, and use of water filters. Also, the pricing policy of municipal water services was examined.

Keywords: Contingent valuation method, total economic value, water management, West Bank, willingness to pay

1. INTRODUCTION

Over the past four decades the Palestinian territories of the West Bank and Gaza Strip (WBGS) have suffered from water scarcity (Elmusa 1993; PWA 2005). The crisis of water scarcity is only one in the WBGS, poor quality of water supply and the absence of proper assessment make a profound impact on the Palestinian economy (Bellisari 1994). Supply of and demand for waters in the West Bank (WB) are in an increasing deficit while the consumption of waters is growing, and the amount of available water could not bridge the gap of shortage (PWA 2005).

The overall objective of the study is to undertake an empirical work dealing with the municipal water for domestic purposes in the WB. The study will examine water management. This study, however, is an important and necessary because:

Pricing water resources based on the marginal value of the product will lead to efficient allocation of water (Henry and Bowen 1982). The mean Willingness to Pay (WTP) is appropriate when the efficiency criterion of welfare economics is adopted (Mendonca and Tilton 2000). The study, therefore, undertake a Contingent Valuation Method (CVM) to evaluate the economic efficiency of domestic water uses as an essential element to formulate efficient allocation mechanisms to meet the households' needs of both, sufficient water quantity and acceptable water quality. Additionally, the CVM is regarded as the main method for the valuation of environmental goods including use and non-use values (Mitchell and Carson 1989).

In Palestine water is scarce and vulnerable. Also, water has an economic value only in case its supply is scarce relative to its demand, since if water is unlimited, it will be a free good (Ward and Michelsen 2002). The concept of water as an economic good is simple, like any other good and it has a value to users who are willing to pay for it hence the consumers will use water as long as the benefits due to use of an additional cubic meter exceed the costs so incurred (Briscoe 1996).

Several methods for pricing and allocating water have arisen because marginal cost pricing is hard to implement in practice (Johansson et al. 2002). The study however seeks to formulate a proper water pricing policy based on the WTP principle as background information to be applied in practice.

2. CONCEPTUAL FRAMEWORK

2.1 The Concept of Total Economic Value (TEV)

The concept behind the TEV is that any good or service is constituted of different attributes, some of which are concrete and easily measured, while others may be more difficult to quantify. However, the TEV is broken-down into two main values, those are: use values and non-use values presented below (Marksoo 2007; Rogers et al. 2002).

(a) Use value: this value can be subdivided into direct use value or indirect use value. Direct use value is consumptive, extractive, or structural use value, derives from goods which can extracted, consumed, or directly enjoyed, for instance, direct uses of water include drinking. The indirect use values occur from the natural functioning of ecosystems, for example, an indirect use of water receives is characterized by its fewer benefits those are not traded in any market and are sometimes referred to as un-priced benefits to the water users.

(b) Non-use value: this value could be not easy to describe or to evaluate; it is derived without direct use of a resource. Non-use value can be named as intrinsic value or passive value. The non-use value, however, can be subdivided into existence, bequest, and option value. Existence value measures the WTP for a resource for some moral, altruistic, or other reason which is not related to current or future use. Bequest value is the value a habitant places on the ability to conserve a resource so that it can be used by future generations. The third part of nonuse value is option value; the concept of option value refers to the value placed on a resource's future use.

2.2 Water Management

The Dublin principles were an attempt to concisely state the main issues and thrust of water management, especially, in the developing countries. The four Dublin principles presented below have been universally adopted as main principles for integrated water resources management (IWRM) (Rogers et al. 2002; Marksoo 2007).

- Fresh water is a finite, vulnerable, essential resource to sustain life, development and the environment.
- Water resources development and management should be based on a participatory approach, involving all relevant stakeholders at all levels such as users, planners, and policy makers.
- Women play a central part in the provision, management and water safeguarding.
- Water has an economic value in all of its competing uses.

2.3 The Contingent Valuation Method (CVM)

The CV technique has been used for about twenty years to estimate passive use values. For over the last five years there has been a dramatic increase in the number of academic publications and

presentations related to this technique (Mitchell and Carson 1989). Also, CVM is the most common method for valuing non-market amenities (Arrow et al. 1993).

The Contingent Valuation Method is an example of a hypothetical direct valuation technique non-market valuation requiring the active involvement of respondents. Due to a hypothetical policy change that will cause some environmental impacts, the benefits and costs are evaluated through questionnaire surveys that detect the WTP of consumers to accept or avoid, the policy change in question. The questions maybe open-ended or close-ended, with take frames such as dichotomous choice (leave-it-or-take-it). These values are summed for users and non-users alike, and the net benefits to society estimated. It will be shown subsequently that careful use of the CVM can elicit either use or non-use values for an amenity. Econometric analysis of survey results is generally utilized to derive mean values of WTP bids and to estimate the determinants of respondents' familiar with the asset being valued (Lipton et al.; 1998; O'Doherty 2001; Haab and McConnell 2003).

3. METHODOLOGY OF RESEARCH

3.1 Analysis Techniques and Econometric Models

Descriptive statistics such as frequencies, mean, standard deviation, cross-tabulation, correlation, and one-sample t-test, enhanced by non-parametric tests such as Mann–Whitney U test and Kruskal-Wallis K test were used (the statistical package SPSS was run to test these statistics).

The willingness to pay question format utilized in the CV questionnaire offers the possibility to use a variety of estimating techniques. The discrete choice with follow-up question used to model WTP by using Tobit econometric model, binary-Logit econometric model, and ordinary least squares (OLS) can be utilized (Cameron and Trivedi 2005; Wooldridge 2001). However, Tobit is recommended to use for several reasons presented beneath (Tobin 1958; Cameron and Trivedi 2005).

$$WTP = \begin{cases} WTP^{Tobit} & if\ WTP^{Tobit} > 0 \\ 0 & if\ WTP^{Tobit} \le 0 \end{cases} \tag{1}$$

where, WTP^{Tobit} is unobserved continuous dependent variable, or the unobserved true WTP. Therefore, the Tobit model is an appropriate to avoid endogeneity bias; the empirical WTP model is a simultaneous equations instrumental variables model. The model of WTP is a Tobit regression and the quality or quantity model is an OLS's regression:

$$WTP_i = \alpha' X_{1i} + \beta \hat{q}_1 + \varepsilon_{1i} \tag{2}$$

$$q_i = \gamma' X_{2i} + \varepsilon_{2i} \tag{3}$$

$$\rho = correlation\left[\varepsilon_{1i}, \varepsilon_{2i}\right] \tag{4}$$

where, $\hat{q}_1$ is the estimated variable from the used model for water quantity or water quality. The estimation method is full information maximum likelihood allowing for correlation in the normally distributed disturbance terms ρ, the test for the exogeniety of $\hat{q}_1$ is a t-test for $\rho = 0$

The variables in the X_{2i} vector but not in the X_{1i} vector are the identifying variables. These variables should have high explanatory power in the instrumenting equation and low correlation with WTP and the disturbance term. Coefficient values estimated using Tobit technique may differ

substantially in both, magnitude and sign, from those estimated by using ordinary least squares. The marginal effect of an autonomous variable, say m, on $E(WTP)$ is $\frac{\delta E(WTP)}{\delta m} = \beta\Phi(Z)$, where Z is evaluated at the mean of all variables including quality or quantity in accord with the desired dependent variable. Since, $0 < \Phi(Z) < 1$, the marginal impact will always be smaller in absolute value than the coefficient estimate (E-Views software econometric package was utilized).

3.2 CV Design and Survey Administration

In developing countries the use of CVM to measure the WTP for social projects is well accepted and widely utilized in many different circumstances, but some biases may exist when using this technique. Those biases are due to the hypothetical nature of this method. Careful survey design is necessary to avoid such problems (Whittington 1998; Whittington 2002).

This empirical study was undertaken a CV technique to measure the TEV of domestic water services including both, use values and non-use values.

The scenario used for face-to-face (in-person) interviews in this study administrated to value the water quantity and water quality in Ramallah governorate. The dichotomous choice is followed by an open-ended follow-up question, for instance, "what is the maximum that you are willing to pay …?" was used in the survey questionnaire of CV (Freeman 1993; Arrow et al. 1993; Mitchell and Carson 1989; Haab and McConnell 2003).

A stratified random sample was utilized to ensure a representative sample of households, chosen from the governorate of Ramallah for dividing the households into three main sub-groups. Three divisions (strata) and a representative sample for each stratum were randomly selected: (a) household heads who live in the cities of Ramallah and Al-Bireh; (b) household heads of rural areas; and (c) household heads who live in the refugee camps. After dividing the study population into the appropriate strata, a simple random sample was taken across each stratum.

The usable sample is composed of 520 household's heads, 1.5% of the households census for each stratum was taken to befit the size of the population, since the sample was administrated to the household's heads in the cities, villages, and refugee camps.

3.3 Administration of Water Institutions Survey

The study was also undertaken a second survey which was directed to the employees of water institutions for evaluating the pricing policy adopted from the water institutions. A stratified random sample is to ensure a representative sample of all management personnel, was chosen in the local councils and Jerusalem Water Undertaking (JWU). An important element of the features that we might want our sample is to show a proportional representation of different positions in which employees work. Specifically, the target sample was divided into three levels (strata): (1) senior management; (2) management department; and (3) Finance department. Since, the target sample was directed to the JWU, the municipalities of Ramallah and Al-Bireh, and fourteen Local councils in Ramallah governorate, which are the large village local councils. Due to dividing the personnel into three appropriate strata, a simple random sample was taken through each stratum.

A stratified sample of 117 employees in the water institutions was selected. The usable sample was targeted employees who have practical experience with municipal water, 70% of personnel were taken for senior managements, 70% of personnel were taken for management departments, and 70% of personnel for finance departments.

4. EMPIRICAL ANALYSIS AND FINDINGS

The CV survey was used for in-person interviews. The survey was interviewed the household

heads (100% of the CV sample). The study used CVM to measure the use and non-use values of domestic water services. As shown in Table 1 and Table 2, the tobit model used the open-ended WTP variable as a dependent variable, which included positive and true zero responses and estimated a mean WTP (Jones et al. 2008). The logit model used the binary WTP variable (0, 1) as a dependent variable (Ojeda et al. 2008).

As Table 1 indicates, the mean WTP value of the tobit model of 518 respondents in the CV survey was obtained as New Israeli Shekel (NIS) 31.4. This result implies that the respondents interviewed are voluntary willing, on average, to pay NIS 31.4 to have sufficient and reliable water supply for the households (use values). The log-likelihood is -1895.051 according to tobit model and is -319.707 according to logit model. Both gave a negative answer, as a desired value for maximum likelihood estimation to seek the probability distribution that makes the observed data most likely (Myung 2003). According to the linear model the adjusted coefficient of determination (adjusted R^2) is 0.11, which is acceptable result for CVM studies (Imandoust and Gadam 2007).

Table 1. Bid curve analysis: Estimated WTP model – The use values of municipal water

	Expected sign of coefficient	*Logit-Estimated coefficient*	*Logit-Z-value (P-value)*	*Tobit-Estimated marginal effect*	*Tobit-Z-value (P-value)*
Constant		1.478	*2.617 (0.008)*	*21.871*	*1.654 (0.098)*
Age	+/-	0.094	*0.842 (0.399)*	*4.274*	*1.579 (0.114)*
Gender	+/-	0.124	*0.556 (0.577)*	*4.668*	*0.858 (0.390)*
Location - Urban	+	0.047	*0.201 (0.840)*	*4.206*	*0.744 (0.456)*
Location - Rural	-	-0.253	*-1.167 (0.243)*	*-10.928*	*-2.118 (0.034**)*
Time-period	+	-0.011	*-1.506 (0.131)*	*-0.293*	*-1.553 (0.120)*
Water consumption	-	-0.009	*-2.037 (0.041**)*	*-0.258*	*-2.145 (0.031**)*
Income	+	0.0001	*2.273 (0.023**)*	*0.006*	*4.471 (0.000*)*
Education	+	0.047	*0.460 (0.645)*	*-0.307*	*-0.120 (0.904)*
Employment Status	+	-0.785	*-2.077 (0.037**)*	*-13.008*	*-1.559 (0.118)*
Gainfully employed	+	-0.277	*-1.872 (0.061***)*	*-4.810*	*-1.326 (0.184)*
Household size	-	-0.049	*-1.140 (0.253)*	*-1.311*	*-1.178 (0.238)*
The use of water filters	+	0.924	*4.216 (0.000*)*	*19.233*	*3.881 (0.000*)*
Log-likelihood = -1895.051 (Tobit model) Observations = 518 Mean WTP = NIS 31.4					
Adjusted R^2 = 0.11, R^2 = 0.13					

*Significant at the 0.01 level, **Significant at the 0.05 level, ***Significant at the 0.10 level of confidence.

The results revealed that the variable water consumption, the use of water filters and income have significant impact on WTP, since income and the use of water filter have a positive impact, while consumption has a negative effect on WTP (the more I consume the less I am willing to pay), which seems to be consistent with the findings in other studies and the economic theory. The rural areas have a negative and significant impact on WTP; this implies that the rural respondents are unlikely to be willing to pay (WTP) for improved municipal water supply (Piper 1998; Farolfi et al. 2007; Zhongmin 2003). But the variable employment status and gainfully employed "the family members who are gainfully employed" have significant and negative impact on WTP, which is to be contradictory to the findings in other studies (Mendonca and Tilton 2000; Jones et al. 2008). The variable urban location, time-period "how long the respondent has lived in the region?", educational level, and household size have insignificant impact on WTP, which is to be inconsistent with the findings in other studies that have a significant impact on WTP (Kaoru 1993; Mendonca and Tilton 2000; Mbata 2006; Ojeda et al. 2008; Zhongmin 2003). The variable age and gender also have insignificant impact on WTP.

On the other hand, tobit model shows the marginal effect "elasticity" of income is 0.006 and less than 1, as a result, the respondent's WTP change for income change is likely to be very low and limited. Also, according to Kruskal-Wallis K test the mean rank reveals respondents who live in the refugee camps are likely to be WTP more than rural and urban areas, although urban and rural respondents have a level of income, which is higher than the income level of the refugee camps' respondents. This result was mainly because of: the networks and reliability of water supply in the refugee camps are bad compared with urban and rural areas.

The data also showed that the respondents encounter a crisis of water in terms of both, quality and quantity. As the majority of respondents revealed that the government should proceed to solve the problem of both, water quantity and quality in parallel.

As Table 2 indicates, the mean WTP value of the tobit model of 518 respondents in the CV survey was obtained as NIS 20.8. This result implies that the respondents interviewed are voluntary willing, on average, to pay NIS 20.8 to insure water for future generations (non-use values). The log-likelihood is negative, as a desired value for maximum likelihood estimation (Myung 2003). The R^2 is 0.092, which is accepted result for CVM (Imandoust and Gadam 2007).

Table 2. Bid curve analysis: Estimated WTP model – The non-use values of municipal water

	Expected sign of coefficient	*Logit-Estimated coefficient*	*Logit-Z-value (P-value)*	*Tobit-Estimated marginal effect*	*Tobit-Z-value (P-value)*
Constant		0.248	0.459 (0.645)	-8.434	-0.718 (0.472)
Age	+/-	0.040	0.377 (0.705)	2.683	1.124 (0.260)
Gender	+/-	0.136	0.621 (0.534)	2.604	0.544 (0.586)
Location - Urban	+	0.469	2.01 (0.044**)	8.852	1.828 (0.067***)
Location - Rural	-	-0.458	-2.157 (0.03**)	-2.057	-2.057 (0.039**)
Time-period	+	0.004	-0.596 (0.550)	0.060	0.364 (0.715)
Water consumption	-	-0.0148	-2.915 (0.003*)	-0.265	-2.489 (0.012**)
Income	+	0.000046	0.938 (0.347)	0.002	2.265 (0.023**)
Education	+	0.162	1.607 (0.107)	3.164	1.453 (0.146)
Employment Status	+	-0.201	-0.567 (0.570)	-2.480	-0.320 (0.748)
Gainfully employed	+	-0.157	-1.092 (0.274)	-1.233	-0.387 (0.698)
Household size	-	-0.045	-1.044 (0.296)	-0.863	-0.900 (0.367)
The use of water filters	+	0.823	3.920 (0.000*)	15.739	3.698 (0.000*)
Log-likelihood = -1641.168 (Tobit model) Observations = 518 Mean WTP = NIS 20.8					
Adjusted R^2 = 0.072, R^2 = 0.092					

*Significant at the 0.01 level, **Significant at the 0.05 level, ***Significant at the 0.10 level of confidence.

The outcomes also revealed that the variable water consumption, the use of water filter and income have significant impact on WTP, since income and the use of water filter have positive impact while consumption has a negative effect on WTP. The variable location showed that the rural respondents have a negative and significant impact, while urban respondents have significant but positive impact on WTP; this implies that the urban respondents are likely to be WTP for insured water for next generations, but the rural respondents are unlikely to be WTP. These results are consistent with the findings in other studies (Piper 1998; Zhongmin 2003; Farolfi et al. 2007). The variable educational level, time period "how long the respondent has lived in the region?", employment status, gainfully employed "the family members who are gainfully employed" and household size have insignificant impact on WTP , which seems to be inconsistent with the findings in other studies (Mendonca and Tilton 2000; Gopalakrishnan 2003; Mbata 2006; Ojeda et al. 2008). The variable age and gender also have insignificant impact on WTP.

The study also revealed that the majority of respondents are unlikely to deal with water as an economic good that has an economic value. However, the study findings showed that there is a contradiction regarding this issue. According to one sample t-test, although the most of the

respondents revealed that the total revenue of water selling should recover the total costs and encouraged imposing financial penalties or fines on households, which have higher level of water consumption compared with other households, there are more than a half of the respondents prefer to get on water in a low price, which is insufficient to cover the average costs of water.

On the other hand, in the course of the study a second survey was undertaken. This survey consisted of interviews of the employees of water institutions (100% of the sample). It was used to evaluate the pricing policy adopted in the water institutions. However, according to one sample t-test, the adopted pricing policy in the water institutions is designed to achieve cost recovery, in other words, to recover at-least the minimum level of average costs per unit of water sold. In contrast, the water institutions don't take the negative externalities resulted from water uses such as infections or water degradation into consideration through the pricing policy. Also, the water institutions, especially, the JWU adopt a graduate pricing system in harmony with all consumer social categories to facilitate payment of water bills (water prices increases proportionally with increase of consumed water quantities).

5. CONCLUSIONS

This study is one of the few that has utilized CVM for improved water quality and secured sufficient water supply (use values), since a CVM survey was also used to obtain estimates of WTP for sufficient water for future generations (non-use values) in the WB.

Households are voluntarily WTP, but only NIS 31.4 monthly an insignificant amount in increased water costs for reliable water supplies that based on the coefficients of the explanatory variables explained below, since the mean WTP was NIS 31.4 per month of each household. Additionally, they are voluntarily WTP, but only insignificant amount for reliable water supply for future generations, since the mean WTP was NIS 20.8 monthly of each household-head. These WTP estimates are likely to increase the respondent's current monthly water bill (Mendonca and Tilton 2000).

Regressions' outcomes also show that respondents who have a high level of income and/or use water filter in the households are likely to be WTP for both: improved water quality and reliable water quantity (use values) and also for water conservation for future generations (non-use values).

Households which have high level of water consumption are unlikely to be WTP for use and non-use values. Rural respondents were unlikely to be WTP for use and non-use values of domestic water services, while urban respondents are likely to be WTP for non-use values. According to Kruskal-Wallis K test, there is a gap among cities, villages, and refugee camps in terms of WTP, since respondents of urban areas and refugee camps are likely to be WTP. Moreover, the percentage change of WTP with respect to income change was very low.

Households which are gainfully employed are unlikely to be WTP for non-use values. On the other hand, the variable age, gender, education, time period "how long the respondent has lived in the region?", and household size have insignificant impact on WTP.

In general, as a result of water scarcity and the unique situation of Palestine the households could accept to deal with water as an economic good, but they dislike affording more than what they are paying currently. However, it seems the respondents are unlikely to deal with water as an economic good at present.

This study also revealed that the main water institutions adopt already graduate pricing system for water and interested to attain the minimum level of average costs at-least, but they neglect to consider the environmental costs as a part of the total costs of water.

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