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Full Length Research Paper

Willingness to Pay (WTP) for pipe-water connection in Makululu compound of Kabwe, Zambia

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The availability of safe drinking water is dependent on better and improved water sources for households. Access to safe drinking water especially piped water is one of the challenges faced by households in Zambia. This study aims to understand the factors that determine the willingness to pay for pipe water connection on low income peri-urban settlements in Zambia. Double bounded questions which have the advantage of including a follow up dichotomous question after the first dichotomous choice question are used. An interval regression model is used to analyze the collected data. The variables of interest are purification, family size, water quality, education and income. The results obtained show that most of these variables have the expected signs. Further, the results suggests that an increase in income will lead to an increase in the willingness to pay to have access to safe drinking water sources. The results also suggest that the distance travelled to fetch water from a community tap and level of household education play a role in the willingness to pay for access to pipe water connection. We estimated that the sample household mean WTP is K283.77 ($38.14) which is roughly 33% of the commercial connection charge.

Keywords: Contingent valuation, double-bounded, interval regression, WTP, Zambia.

INTRODUCTION

Water is essential for human survival. It is for this reason that in 2010, the United Nations General Assembly declared safe and clean drinking water and sanitation a human right essential to the full enjoyment of life and all other human rights (UNICEF, 2014). Notwithstanding its importance, access to improved water still remains a challenge to access safe drinking water. As a result, most people continue to be exposed to waterborne diseases such as cholera, diarrhoea, dysentery, typhoid fever among others. According to the World Health Organisation (WHO), water borne diseases are among the major causes of morbidity and mortality in most developing countries particularly among children under five years old. Contaminated drinking water is estimated to cause 502, 000 diarrhoea death each year (WHO, 2016).

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Zambia has made progress in increasing access to improved drinking water. The proportion of the population with access to an improved source of drinking water increased from 24 percent in 2007 to 65 percent in 2014 (ZDHS, 2015). Table 1 below shows that, the percentage of total population piped into dwelling/yard/plot stands at 16 percent in 2014. The progress has been necessitated by the various programmes that the government together with its cooperating partners have implemented such as the National Rural Water Supply and Sanitation Program (NRWSSP) and National Urban Water Supply and Sanitation Program (NUWSSP). Despite this progress, access to improved drinking water in general and piped water in particular continues to be a challenge in Zambia. In comparison to its neighbouring countries, as is shown in Table 2 (Annex), Zambia has among the lowest levels of access to drinking water.

The health and time saving benefits of access to clean water, as private or communal, by households in developing countries have been widely documented. Our main objective in this study is to assess their willingness to pay for private pipe-water connection. This is because of the fact that households in our study site already had access to clean water from communal taps supplied by the water utility company. Thus study sought to estimate willingness to pay for improved water supply through pipe water connection in Bwacha constituency, Kabwe, and to determine the factors (variables) that influence households' WTP for improved water supply. Makululu is an unplanned settlement characterised by lack of social amenities such as piped water among others.

The Contingent Valuation Method (CVM) is used to estimate monetary measure of preference by directly asking respondents' willingness to pay for changes in quantity or quality of a good or service ((Haab & McConnell, 2002)). The Dichotomous Choice Contingent Valuation Method (DC–CVM) can be presented in different forms. The single bounded DC–CVM asks respondents for a predetermined bid amount for their vote or rejection. Alternatively in double bounded format we offer a follow-up price (bid) for the respondent after getting a response for the initial bid. The follow-up bid in double bounded take a higher value if the respondent's answer for the first bid was YES and a lower value if the answer was NO.

Estimation of household's demand for water usually conducted by capturing key indicators of household characteristics. Nauges and Whittington (2010) well documented the various empirical researches made on water demand in various countries. Recent notable studies in African countries, using various methodologies, have established that income, family size, time spent to fetch water from existing sources, level of education, age of respondent, bid value, perceived quality of current water supply are the main factors influencing households WTP for improved water supply services (Gulyani et al. 2005; Tarfasa and Brouwer, 2013, 2015; Genius et al 2008.)

Despite the fact that various studies have been undertaken to determine the willingness to pay and the factors that determine the willingness to pay (WTP) for quality water in developing countries around the world, we didn't find enough literature relating to WTP for improved water in Zambia particularly employing the CVM. One particular study done in the North Western Province of Zambia by Aymar (2004) using descriptive analysis concluded that willingness to pay depends to a large extent on income level. The higher the income, the higher willingness to pay.

The paper proceeds as follows. In the next section we present the model of willingness to pay. Section 3 discusses study site and sampling technique. Sections 4, 5 and 6 are for results, discussion and conclusion respectively.

METHODOLOGY

Willingness to Pay Model

An application of a contingent valuation questionnaire using the dichotomous choice model renders two answers. These are dichotomous answer ($y_i = 1$ if the individual answers yes and $y_i = 0$ if the answer is no) given a question about paying a predetermined amount of t_i.

The WTP can be estimated by modelling as the following linear function:

$$WTP_i(z_i, u_i) = z_i^{'}\beta + u_i \quad (1)$$

Where z_i is a vector of explanatory variables, β is a vector of parameters to be estimated and u_i is the error term. The respondent will answer *yes* when his WTP is greater than the suggested amount that is when $WTP_i > t_i$.

WTP and Double-bounded contingent valuation

We can assume that an individual is asked if he is willing to pay an amount t_i for a given change in the provision of a given good or service. If the individual answers *no* then we can infer that $-\infty \leq WTP < t_i$, if he answers *yes* then $t_i \leq WTP < \infty$.

But Hanemann et al. (1991) suggested that the follow-up dichotomous question can be asked after the first dichotomous question. This approach, called double-bounded models, is assumed to generate more efficient estimation than a single question or a single question followed by an open ended question. In the case of double bounded model, a follow-up dichotomous question is asked after the first dichotomous choice question. If the individual answers *yes* to the first question then he/she is asked about his WTP for a higher amount. If he answers *no* to the first question then a lower amount is offered. The second questions is endogenous in the sense that the amount asked depends on the answer obtained for the first question which is exogenous. The method renders with two answers for each respondent.

If we call the first bid amount t^1 and the second one t^2, where $t^2 < t^1$ then

i. The individual that answers *yes* to the first question and *no* to the second, then $t^2 > t^1$. This implies $t^1 \leq WTP < t^2$.

ii. If the answers are *yes* for both questions, then $t^2 \leq WTP < \infty$.

iii. If the individual's answer are *no* to the first question and *yes* to the second, then $t^2 \leq WTP < t^1$.

iv. Finally, if the individual's responses are *no* for both questions, then we will have $0 \leq WTP < t^2$

Econometric estimation of double-bounded or interval data model

Let's define y_i^1 and y_i^2 as the dichotomous variables that capture the response to the first and second closed questions, then the probability that an individual answers *yes* to the first question and *no* to the second can be

Table 1. Use of drinking water sources (percentage of population) as of 2015: selected countries.

Country	Urban		Rural		Total	
	Total improved	**Piped on premises**	**Total improved**	**Piped on premises**	**Total improved**	**Piped on premises**
Botswana	99	96	92	45	96	74
South Africa	100	92	81	38	93	73
Namibia	98	69	85	34	91	51
Malawi	96	33	89	3	90	8
Zimbabwe	97	74	67	5	77	28
Swaziland	94	75	69	27	74	37
Zambia	*86*	*36*	*51*	*2*	*65*	*16*
Congo, Dem. Rep.	81	17	31	1	52	8
Mozambique	81	25	37	1	51	9

Source: UNICEF and WHO, 2015.

Table 2. Socio-economic characteristics of surveyed households.

Variable Name	Description	Frequency	Percent
Gender	*Gender of the respondent*		
	Female	63	42
	Male	87	58
Education	*Educational level of the respondent*		
	No formal education	8	5.3
	Primary	46	30.7
	Secondary	68	45.3
	Tertiary	28	18.7
Family size	*Number of family members living in the household*		
	Less than 5	84	56
	5 up to 10	62	41.3
	More than 10	4	2.7
Income	*Average monthly income*		
	Less than K100	9	6
	K100 – K150	30	20
	K150 – K200	30	20
	More than K200	80	53

expressed as $\Pr(y_i^1 = 1, y_i^2 = 0|z_i) = \Pr(s,n)$.Given this and under the assumption that $WTP_i(z_i, u_i) = z_i'\beta + u_i$ and $u_i \sim N(0,\sigma^2)$, the probability of each one of the cases is given by:

$$y_i^1 = 1, y_i^2 = 0$$

$$Pr(s,n) = Pr(t^1 \le WTP < t^2)$$

$$= P(t^1 \le z_i'\beta + u_i < t^2)$$

$$= Pr\left(\frac{t^1 - z_i'\beta}{\sigma} \le \frac{u_i}{\sigma} < \frac{t^2 - z_i'\beta}{\sigma}\right)$$

$$= \Phi\left(\frac{t^2 - z_i'\beta}{\sigma}\right) - \Phi\left(\frac{t^1 - z_i'\beta}{\sigma}\right)$$

Using symmetry of the normal distribution:

$$\Pr(s,n) = \Phi\left(z_i'\frac{\beta}{\sigma} - \frac{t^1}{\sigma}\right) - \Phi\left(z_i'\frac{\beta}{\sigma} - \frac{t^2}{\sigma}\right)$$

The other three probabilities, the probability that an individual answers $Pr(s,s);\ Pr(n,s);\ Pr(n,n)$ are also captured in a similar fashion.

Then, a log-likelihood function can be used to estimate β and σ using maximum likelihood estimation.

$$\sum_{i=1}^{N}\left[I_i^{s,n}\ln\left(\Phi\left(z_i'\frac{\beta}{\sigma} - \frac{t^1}{\sigma}\right) - \Phi\left(z_i'\frac{\beta}{\sigma} - \frac{t^2}{\sigma}\right)\right) + I_i^{s,s}ln\left(\Phi\left(z_i'\frac{\beta}{\sigma} - \frac{t^2}{\sigma}\right)\right) + I_i^{n,n}ln\left(1 - \Phi\left(z_i'\frac{\beta}{\sigma} - \frac{t^2}{\sigma}\right)\right)\right]$$

Where $I_i^{s,n}$, $I_i^{s,s}$, $I_i^{n,s}$ and, $I_i^{n,n}$ are the dummy variables 1 and 0 denoting the group to which the i^{th} respondent belongs. A given respondent contributes to the logarithm of the likelihood function in only one of its four parts.

Description of study area

Our study is conducted in Kabwe, one of the 11 districts of the Central province of Zambia. The specific locality, Makululu Compound in Bwacha constituency, is an unplanned settlement located in Kabwe district of lying between latitude 14° 27' S and longitude of 28° 27'E. It is along the Great North Road, 139 kilometers North East of Lusaka. Kabwe was established as a Lead and Zinc mining town around 1902 and almost all of the mines were closed in mid 1990s that created high unemployment and poverty level on sizable residents. The total population of Bwacha constituency in 2010 was85, 397that belongs to 17,185 households (CSO, 2011:25). The settlement can be described as poor housing units made of mud, with poor sanitation and safe drinking water supply. Poor sanitary practices, like disposal of human excreta usually leads to contamination of water and therefore water-borne diseases Phiri (2016). Majority of the population are not in the formal employment sector with low levels of professional skills and education.

We have applied a stratified and systemic sampling techniques for the primary data collection. There are five wards in Makululu compound and three wards were considered to reach 150 respondents. These were Makululu ward, Chililalila and Moomba Ward. A pre-test was conducted on 5 households to confirm the applicability of the questionnaire in general and the contingent valuation technique in particular. It was found that all the questions including the WTP bids were easily understood by the respondents. For the final data collection, proportionate stratified sampling was applied and each ward had fifty households sampled.

RESULTS

Descriptive statistics

This section discusses both the descriptive statistics and the regression estimation. It also includes explanations of the variables which are used for describing and estimating the willingness to pay for pipe water connection in Bwacha. Furthermore, the section discusses the relevant variables used for the WTP estimation.

The respondents were given a brief introduction of the benefits from connecting to a commercial water pipe line. A total of 150 respondents were asked double bounded questions with K200 being the initial bid and K100 and K500 were the follow-up bids. We did not find anyone opposed the proposed project of private pipe water connection. Table 3 (see Annex)shows frequency and percent of selected variables to describe the sample respondents. The sample respondents are more male, educated, and moderate family size & income.

Table 4 (see Annex) shows that majority, 70%, of the respondents are fetching drinking water from communal taps built by the utility company Lukanga Water and Sewerage. The responses on the assessment of water quality shows that 65(43.3%) and 83(55.4%) of the respondents feel that the water quality is good and very good respectively. This perception of the quality of drinking water also reflected by high percentage, 86.7%, of respondents who are not using any water purification method. For three quarter (75%) of the respondents it takes more than 7 minutes to fetch water from the nearest communal tap. Out of this percentage, 20% of the respondents need to walk for more than 30 minutes to access the communal tap. A more than 10 minutes walking is usually estimated as more than 1 kilometre (0.6 miles) with a normal walking style of an adult person.

Majority of our respondents have access to communal taps (70%) as their primary source of drinking water and they perceived the quality as good and very good (98%). The high rating of the water quality correlate with less tendency to use water purification techniques (13%). Though the majority of the households have access to communal tap water, they need to walk more than a kilometre. Given most of them need to fetch water more than once per day, the time cost of fetching water is high.

Table 5 below shows frequency and percentage of the double bounded responses as 'yes-yes', 'yes-no', 'no-yes' and 'yes-yes'. The bids were preceded by WTP question stated as:

'It is difficult to state the actual cost of connecting your household to the nearest water network. The prices stated below are chosen simply for the purpose of our study. If you are willing to be connected to the water system, are you willing to pay a one-off out of pocket payment?'

Table 6 shows summary statistics of each independent variable used in the interval regression model which is presented in table 7. These variables are expected to affect the WTP for safe drinking water. Water quality, family size, education level and income are expected to have a positive sign in the regression model.

Regression Estimation

Table 7 presents results from a double bounded interval-regression estimation. We made the estimation using Stata's intreg censored regression command. The table presents the coefficient (marginal WTP), standard error, significance level, and confidence interval. We found that the overall model is statistically significant as measured by log likelihood and wald chi square.

Most of the estimated coefficients have the expected signs. According to the estimation result, education level and income level of the household are positive in sign and statistically significant at 5% and 1% respectively.

Table 3. Water source, perceived quality, purification and estimated time to fetch.

Variable Name	Description	Frequency	Percent
Source	*Source of drinking water*		
	Hand dug well	2	1.3
	Borehole	43	28.7
	Communal tap	105	70
Water quality	*Respondent's perception of current water quality*		
	Poor	2	1.3
	Good	65	43.3
	Very Good	83	55.4
Purification	*Water purification method used*		
	Chlorination	11	7.3
	Boiling	7	4.7
	Filtration	2	1.3
	No purification	130	86.7
Time	*Time taken to fetch water from the nearest source*		
	Less than 7 minutes	38	25.3
	15 – 20 minutes	51	34
	20 – 30 minutes	30	20
	30 – 40 minutes	19	12.7
	More than 40 minutes	12	8

Table 4. Distribution of double bounded responses for initial amount of K200 and follow-up K500.

Responses	Number of responses	Percentage
Yes –Yes	33	22.0
Yes – No	46	30.7
No – Yes	33	22.0
No-No	38	25.3

Table 5. variables used in the regression and their expected signs.

Variable	Type	Description	Mean	Std. Dev	Sign
Educational level	Ordered categorical	0 if primary; 1 if basic; 2 if secondary; 3 if tertiary	1.782	.066	+
Income per month	Ordered categorical	0 if <K100; 1 if K100-K150; 2 if K150-K200; 3 if >K200	2.217	.079	+
Family size	Ordered categorical	0 if 1 – 5; 1 if 5 – 10; 2 if >10	0.60	.057	-/+
Distance from the nearest community tap (in minutes)	Ordered categorical	0 if <7 ; 1 if 15-20; 2 if 20-30; 3 if 30-40; 5 if >40	1.414	.098	+
Purification	Nominal	0 = no purification; 1=purification	.92	.021	+

Whereas distance has a negative sign and is statistically significant at 5%

Mean WTP Estimation

The estimation of mean WTP is made using the mean values and the marginal WTP values of the variables used in the regression estimation.

The estimated mean WTP for the 147 sampled households is K283.7748 ($38.14). The estimate of the mean WTP for the pipe water connection can be used to estimate the total benefits in the specific locality. Consequently, we attempted to expand the sample WTP estimate for the population of Bwacha. According to the Central Statistics of Zambia (CSO, 2011), there were 17,185

Table 6. Interval regression estimation.

Interval regression			Number of obs = 147		
Wald chi2(5) = 47.31					
Log pseudolikelihood = -218.0028 Prob> chi2 = 0.0000					
	Coef.	Robust Std. Err.	z	P>|z|	[95% Conf. Interval]
educ	50.81731	22.35321	2.27	0.023*	7.00583494.62879
income	78.70924	14.73437	5.34	0.000**	49.83042107.5881
famsize	29.74863	23.38308	1.27	0.203	-16.0813775.57863
distance	-98.20083	41.97465	-2.34	0.019*	-180.4696-15.93202
purify	-73.84673	79.13106	-0.93	0.351	-228.940881.2473
_cons	143.1545	97.65233	1.47	0.143	-48.2405 334.5496
/lnsigma	5.220299	.0648312	80.52	0.000	5.093232 5.347365
Observation summary:	0 left-censored observations				
	0 uncensored observations				
	32 right-censored observations				
	115 interval observations				

*Significant at 5%, ** significant at 1%.

Table 7. Estimated mean willingness to pay (WTP).

Mean WTP	[95% Conf. Interval]	
283.7748 (USD 38.14)	248.7927	318.7568

Table 8. Aggregate willingness to pay (WTP) of tap water connection in Bwacha, Zambia.

Bwacha residents household mean WTP	[95% Conf. Interval]	
4, 876, 669 (USD 655, 466)	92308.54	93210.62

households in Bwacha in 2010. Multiplying the 810 households by the mean WTP and it yields a total of approximately K4, 876,669 ($655,466), as shown in the following table.

DISCUSSION OF RESULTS

Interval regression model was used to investigate factors determine household's WTP for tap-water connection. The analysis result also includes the estimation of WTP for sample households and the population.

The interval regression model shows that education level and household's monthly income are the significant explanatory variables at 5% and 1% respectively. This is consistent with other studies (Jianjun et al. 2016; Parveen et al 2016; Twerefou, et al. 2015; Mezgebo and Ewnetu, 2015; Coster and Otufale 2014; Kwak et al. 2013; Khan et al. 2010; Mbata 2007) which showed that education and income are significant determinants of WTP. Education enlightens people about the importance clean water while income provides the households with ability to pay for the water. The type of purification technique used, the assessment of current water quality and family size found to be statistically insignificant to WTP for private water pipe-line connection.

It is found that the mean WTP for sample households is K283.77. This amount is a little higher than the estimated average households' income that falls in the range K150 – K200. This confirm that the household's expression of willingness to pay is within their capability to pay. Depending on the sign and magnitude of the coefficient of the variable, it is possible to forecast the change in WTP for a unit change of the variable concerned. For instance, the income variable is measured as ordered category between 0 and 3, as one unit change represent a change in income of K50. Therefore, based on the mean WTP estimation, a one-unit increase in income category adds K78.70 to WTP.

The major contribution of this research is that it adds to the literature on willingness to pay estimation for Zambia where there remain evidences of WTP are scarce. To the best of the authors', this study is the first of its type to apply double bounded discrete choice model with interval regression to pipe water connection in Zambia.

CONCLUSION AND POLICY IMPLICATIONS

In this study we examine to what extent characteristics of the respondents (the household head) determine the likelihood that they are willing to pay a given amount of money for pipe water connection. The study used a double bounded contingent valuation method to estimate willingness to pay (WTP) for pipe water connection in Bwacha constituency, Zambia. The main objective of this study was to understand the factors that determine the willingness to pay for safe drinking water in a low income urban settlement in Zambia. An interval regression model is used to estimate coefficients of the variable and the WTP.

The regression estimation result shows that most of the variables found to have expected signs. Among the five variables considered, two variable, namely income and education level of the respondents are statistically significant in determining the WTP for safe drinking water connection. The mean WTP of income is estimated to be K283.77 for a household. The Lukanga water company, the sole utility company in Kabwe, has a fixed pipe water connection rate based on the distance between a house and the nearest main pipe-line. Those houses within 10 meters distance from the main pipe-line are charged K852 and the rate increases as the house located more than the 10 meters distance. Our estimation of mean WTP is roughly 33% of the connection charge.

The findings of the study are vital for utility company, development partners and local government authorities. The connection charge for most households is 'expensive.' Nevertheless, our research found that, with some financial or reduced connection charge, it is possible to provide access to safe drinking water to many urban dwellers who are deprived of these essential life sustaining resource for many years. Attainment of more years of formal education plays a paramount role in creating awareness about the many advantages of living a healthy life by committing resources by acquiring utilities like water. The study demonstrated the applicability of contingent valuation method to assess the demand and willingness to pay for access to safe

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drinking water in developing country like Zambia. Future research works should attempt to use other WTP estimation techniques to extend our findings.

DISCLOSURE

The authors declare no conflict of interest.

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