Demand for Domestic Water from an Innovative Borehole System in Rural Ghana: Stated and Revealed Preference Approaches.

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Abstract

This study investigates demand for domestic water supply from an innovative borehole system using the Contingent Valuation Method (CVM). We further estimate demand for current service of domestic water supply in residences using the Hedonic Pricing Method (HPM). This is achieved through a survey from rural districts of the Greater Accra Region, Ghana. Interval regression and ordinary least squares (OLS) are applied to investigate the determinants of willingness-to-pay (WTP). We find that monthly WTP are GH¢35.90(US$11.45) and GH¢17.59(US$5.61) in the CVM and HPM, respectively. These values constitute approximately 3%-6% of household monthly income which is consistent with earlier studies. For policy purposes, the study recommends the adoption of this cost effective technology to help ease the water burden on society.

Key words: Interval Regression, OLS, CVM, HPM, WTP, Rural-water, MDGs, SDGs.

1. Introduction

In the Millennium Development Goals (MDGs), one of the first targets to have been declared met was the Drinking Water Target. However, rural areas across the world especially in developing countries still lag behind in access to clean drinking water. UNICEF/WHO (2014) reports that, 97 out of every 100 people from rural areas in developing countries do not have piped-water, with 14% depending on surface water such as rivers, ponds, or lakes. Sub-Saharan Africa (SSA) needs more attention as it has a worse case relative to other developing regions. It is estimated that only 61% of people in SSA have access to improved water supply relative to over 90% in Latin America and Caribbean, Northern Africa, and large parts of Asia. Indeed, SSA lags behind the other developing regions in terms of development towards water supply targets.

Towards meeting MDG 7 which has further been consolidated into Sustainable Development Goal 6 [1], groundwater is considered a reliable improved source for domestic use in SSA. MacDonald et al. (2002) provide some insights into groundwater as a reliable improved option especially in low permeability areas in Africa. They argue that groundwater is a "well suited" source for rural water supply in SSA. It possesses some resilience to the impacts of drought and is relatively cheap to develop and maintain. One major challenge is the kind of improved groundwater (borehole and wells) being provided. These are generally the traditional manual types, which require a lot of physical strength from water haulers (mainly women and children) to pump and it's mostly without filters hence quality is sometimes compromised because of environmental conditions. The water is further exposed to contamination from the point of access to the point of usage. It is important to acknowledge that recent evidence indicates that many improved water supplies suffer from poor reliability (Hunter et al., 2009), and that not all improved water is safe (Levisay and Sameth, 2006). In the view of MacDonald et al. (2002), some proportion of trace constituents in groundwater can make it unsafe and can give rise to health problems. Yet such sources can erroneously be described as improved or safe sources of water. This, to some extent, brings doubts as to whether what is described as 'improved' by the international community is the same as 'safe[1]'.

In Ghana, the Community Water and Sanitation Agency (CWSA) is the national institution responsible for the provision of safe drinking water and related sanitation services to rural communities. Unfortunately, these communities depend primarily on water from traditional borehole systems which can at best be described as 'improved' but not 'safe'. Another key challenge of the CWSA enshrined in the National Water Policy (NWP, 2007) is how to set tariffs to ensure the sustainability of operations as information on consumers' consumption behaviour is unknown to agents in this market.

In order to avoid future uncertainties regarding the supply of safe drinking water to rural dwellers in a more effective and efficient way, this study primarily aims at estimating household's demand for an innovative borehole system given that piped-water systems are not available. This is a completely new kind of borehole system. It uses water pump and it is connected to a solar source of energy supply. The pump generates and supplies water through a filtered-pipe into a communal water tank, which supplies the generated water through a second filtered-pipe(s) to surrounding homes. Thus, we use cost effective resources such as abundant sunshine and ground water which is properly filtered for the design of this innovative system. Water supply from this innovative system can be described as safer and cheaper water relative to what is currently being offered. It has the advantage of easing the water burden on women and children with its associated consequential benefits. In addition, it is particularly useful in developing countries where water supply infrastructure is a major problem. We propose this innovative system to the rural community and provide information about households' willingness-to-pay (WTP).

The competing independent valuation approaches generally accepted and used in literature for determining the economic value of non-market goods and services are either based on the revealed/indirect approaches (such as hedonic pricing method [HPM], travel cost method [TCM], take-it-or-leave-it method [TIOLI] etc.) or stated preference/direct approaches (such as contingent valuation method [CVM], choice experiment method [CE]) (see Adamowicz et al., 1994). These valuation approaches also provide economic measures of social benefits needed to inform policy direction. These methods have been used by prominent institutions such as The World Bank, and applied in both developed and developing countries' contexts (see Briscoe et al., 1990; Bateman et al., 1994; Nauges and Whittington, 2009 etc.). Indeed, it goes without saying that these methods are useful in both settings.

In this paper, we use the CVM through a hypothetical market design, and the HPM using rental values of housing units, to measure different aspects of water supply in the rural Greater Accra Region (GAR) of Ghana. We use the CVM to estimate household's marginal WTP for domestic water supply from the proposed innovative borehole system which captures access to safe water supply whilst the HPM is used to estimate household's marginal WTP for the current service which also captures access to current improved water supply in residences. Results from both methods suggest that, households place higher value on water from the innovative borehole system than the traditional systems. We find that household's monthly marginal WTP estimates are GH¢35.90(US$11.45) and GH¢17.59 (US$5.61) in the CVM and HPM, respectively. In line with the MDGs and Sustainable Development Goals (SDGs), this study provides information to assist policy makers locally and internationally in their decisions for rural water supply in Ghana. This

[1] "Safe drinking water is water with microbial, chemical and physical characteristics that meet WHO guidelines or national standards on drinking water quality" (WHO, 2015@ www.who.int/water_sanitation_health/ mdg1/en). In this study *safe water* is referred to as water supply from piped system or treated borehole water etc., and *improved water* is defined as water supply from boreholes, wells etc. not necessarily treated.

will help evaluate the socio-economic and health potential of the project as well as determine appropriate tariffs for rural communities which can help design socially equitable fiscal policies.

The rest of the paper is structured as follows. Section 2 presents the empirical review of literature. Section 3 describes the survey design used in carrying out the research. Section 4 presents results and discussions while section 5 concludes with relevant policy recommendations.

2. Empirical Literature

In this section, we review studies on WTP which relate to introducing innovative or new products in developing countries and shed light on how studies have been empirically conducted using non-market based valuation methods.

Brouwer et al. (2015) assessed urban and rural demand for gravity-driven membrane (GDM) filter for improved drinking-water supply in Kenya. This was a new technology that had not yet been introduced to the market. Respondents had knowledge about other filters and their associated benefits. However, this technology with its benefits were altogether new to respondents. The new technology was based on an extensively tested ultra-low pressure filtration and flux stabilisation technique. This by design does not require filter cleaning, yet it produces sufficient amount of water to meet 10-40 $Lday^{-1}$as required by the WHO and reduces diarrhoea occurrence among children to a maximum of once a year per child. The study combined two stated preference methods namely the CE and the CVM and found the latter to produce conservative and statistically more efficient estimates. The study found that respondents value the new technology positively relative to their current situation. The marginal WTP values in absolute terms were observed to be consistently higher in urban areas than rural areas because of income effect. They concluded that a differentiated marketing strategy is key to a successful introduction of the product in Kenya.

Berry et al. (2012) sought to estimate the WTP for a new product (Kosim filter, a ceramic water filter) introduced to some selected villages in Northern Ghana. This product was not totally new to the entire region as it had been introduced and sold by Pure Home Water[2] to some areas but not the areas understudy. The respondents were randomly assigned to be offered a water filter applying either the Becker-DeGroot-Marschak (BDM)[3] or TIOLI offer. This represented a more typical market transaction because prior to the original survey, demonstrations were made and respondents were further educated about the health benefits of the new product. The respondents saw how the new product worked, tasted the water generated from the new product and asked questions. They were given two weeks to discuss WTP for the new product with their families before participating in the original experiment. The study found evidence that respondents were generally willing to pay for the new product. In addition, they found strong evidence that the WTP implied by the TIOLI was consistently greater than the BDM mechanism. This was justified on two accounts. First, respondents felt they could influence the future price by bidding low. Second, the TIOLI may anchor respondents to higher valuation bids.

In addition, the absence of bathrooms with flush toilets and its health consequences in rural communities and the need for such new facilities within Northern Vietnam motivated Van Minh et al. (2013) to assess WTP for improved sanitation. The economic valuation technique employed was the CVM. Responses were elicited through the iterative bidding game format which involved two stages. First, a sequence of dichotomous choice questions, second, final open-ended questions.

[2] A Ghana-based Non-profit Organisation.
[3] BDM is a method for measuring utility by a single-response sequential method. It is considered to be an incentive-compatible procedure used in experimental economics to measure willingness to pay.

The sample size used was 370 households. The unit of analysis for the survey were people not having toilets in their residences as of the time of the interview, and were primary income earners as well as decision makers of their respective households. The hypothetical market used comprises descriptions of the good in question (bathroom with a flush toilet and possible benefits). The study found that about two-thirds were willing to pay for an improvement in their current sanitation situations. The economic status of respondents (poor or non-poor) and health knowledge of respondents were the principal influential factors of respondents' WTP.

Another developing country study by Clasen et al. (2004) investigated household demand for water filters with the purpose of reducing diarrhoea in Bolivia. In a six-month trial, water filters were distributed randomly to half of the 50 participating households in the community. The respondents were categorised into controlled group and intervention group. The respondents generally use customary practices for collecting, storing, and drawing drinking water. Half of the respondents were given filters at the inception of the study, and the other half six months later. Information on WTP were elicited by means of a questionnaire, and they obtained a sample of the pre-intervention drinking water for their baseline data analysis. Participants were randomly allocated by lottery. Half allocated to an intervention group and half allocated to a control group. The study used the CVM to assess WTP for the intervention. The mean response for the maximum amount participants would pay for the filter, was equivalent to U.S. $9.25.

Most WTP studies on introducing a new product, have generally followed field experiments and/or hypothetical survey (CVM) methods. However, to the best of our knowledge there is only one study by North and Griffin (1993), which used the HPM to estimate willingness-to-pay for rural water supply. These authors further confirmed the paucity of studies in this area by indicating that HPM has not yet been applied to WTP for water sources by rural households.

The main contribution of our study to this literature is that, it is, to the best of our knowledge, the first study that has applied both CVM and HPM to water supply for rural households. Also, as demonstrated by the various authors in this literature, the relevance of proper description of an innovative product is very critical when dealing with non-market goods. To this end, we used both pictorial and oral approaches for proper description of our innovative borehole system. We observed from our fieldwork that combining both pictorial and oral approaches gave better understanding to respondents. This and other methodological issues are presented in the next section.

3. Survey Design

Household survey data from all the seven districts in rural areas of the GAR was used in this study. We used household responses for the CVM, and housing attributes from the same survey data for the HPM. The total population and number of households in the rural areas of the GAR as reported by the 2010 Population census are 379,099 and 86,090 respectively. We used Yamane (1967) [4] sample size approach to compute the sample size. We oversampled this to 610 households for higher representation of the population. One response was dropped due to significant missing responses, hence a sample size of 609 households was used in this study.

Standard non-market valuation requires that relevant sampling issues (such as technique and sample size) are properly addressed. It is widely known that inappropriate sampling technique could lead to biased estimates. However, with the unplanned settlements in rural GAR, a multistage quota sampling technique was applied (see Whittington, 1998). This was achieved by clustering the region into seven districts, then into communities. We listed these communities in each district following the Town and Country Planning list of communities and randomly selected the households from these communities within the districts of the region. We sampled one in every two houses. According to our quota, we interviewed all households in the sample houses within the randomly selected communities in the districts. In sum, we applied the multi-stage quota probability sampling technique in drawing our sample of 610 from the population.

A large fraction of rural households in the GAR reside in compound houses together with other households. Communal living effects (where resources are shared) in such compound houses cannot be completely ruled out yet, individual household decisions are mostly the responsibilities of the respective household heads. We therefore considered the entire household as a sampling unit and interviewed whoever the household considers as the household head or decision maker. By Ghana Statistical Service[5] definition, the household head is one who is economically and socially responsible for the entire household. The unit of analysis are household heads who live in the district, are 18years and above, and of sound mind. They should have worked within the last five years and are currently employed. However, we also allowed in our sample those who have not worked within the last seven days of the month of the interview. All potential respondents reserved the right to either accept to participate or decline participation.

The questionnaire was designed based on two standard national survey questionnaires from Ghana and the United Kingdom. This was subsequently reviewed by survey experts, economists and legal practitioners. The questionnaire was pre-tested in a pilot survey on two different occasions during in-person or face-to-face interviews. This made it necessary for additional amendments to be made to the questionnaire to suit what was practically feasible during this period. The final version of the questionnaire after amendment can be categorised into six sections. For brevity, we summarise them under three main headings: *personal data of respondent* which comprises all socio-economic and demographic questions; *general water, sanitation and environmental questions* which includes sources of water supply, water use and reliability, types waste disposal forms, and their general knowledge about local and international environmental issues relating to water supply; and *environmental valuation questions* which consists of the various market designs and WTP questions.

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[4] Yamane (1967) sample size determination approach: $n = \frac{N}{1+N(e)^2} = \frac{86090}{1+86090(0.05)^2} = 398$. Where n is the sample size, N is the size of the population, e is the error level or level of precision.

[5] Government of Ghana, Ghana Statistical Service (2012): 2010 Population and Housing Census, Summary Report of Final Results, Sakoa Press Limited, Ghana.

The questionnaire was administered by twenty-five fieldworkers during April-May, 2014, which also includes the training of interviewers and coordinators, pilot survey and data entry.

3.2 Valuation Approaches and Econometric Models Applied

3.2.1 The Contingent Valuation Method (CVM)

According to Portney (1994, p.1), "[t]he contingent valuation method involves the use of sample surveys (questionnaires) to elicit the willingness of respondents to pay for (generally) hypothetical projects or programs". The first CVM survey was designed and implemented by Davis (1963). Unlike the revealed preference methods, the CVM has the advantage of capturing both use and non-use values. The CVM follows the conventional consumer demand theory, which has it that the quantity demanded of a good is a negative function of price, all else being equal. Respondents in our survey, were asked to place value on the innovative borehole system by answering WTP questions. We define respondent's value in line with a standard household utility function which is convenient with cross sectional data. Following Whitehead and Blomquist (2005), we specify a standard consumer's utility maximization function subject to income and prices as:

$$\max_{q} U(q,z) \qquad s.t. \;\; y = z + pq \tag{1}$$

Where y denotes the income of respondent, p and q are the marginal price and quantity of water from the traditional borehole system respectively, and z is a composite of all other goods and services. The solution to the maximization problem in equation (1) leads to the indirect utility function, $v(p,y)$. Alternatively, the minimisation of consumer's budget, given their utility constraints is shown in equation 2.

$$\min_{q} e(z + pq) \qquad s.t. U = U(q,z) \tag{2}$$

Similarly, solution to the problem in equation 2 yields the consumer's expenditure function, $e(p,u)$. This can be inverted to obtain the indirect utility function by recognizing that $v = u$, and $e = y$.

We demonstrate the entire impact upon a household's welfare by the Hicksian compensating surplus, which essentially shows the amount of income that an individual would be willing to pay for water from the innovative borehole system and, as a result, continue receiving the level of utility (u^0) received before the changes. Now the change in the borehole system by introducing the innovative borehole system should be seen as an increment in consumer's expenditure, $q^1 > q$. Indeed, WTP for the increment arises, and this is shown in equation 3.

$$CS(q,q^1) = WTP = e\big(p,q,v(p,q,y)\big) - e(p,q^1,v(p,q^1,y)) \tag{3}$$

We also obtain the compensating surplus function where WTP is a function of some factors,

$$CS(q,q^1) = WTP = e(p,q^1,v(p,q^1,y)) - y \tag{4}$$

Equation 4 (compensating surplus function) represents a measure of WTP for the innovative borehole system as a function of quantity of water from the innovative system and income of households. Thus, it shows how much each household is willing to sacrifice and yet remain on the same utility level (u^0) before the change. For empirical purposes we rewrite the structural economic function given by equation 4 into an econometric function. Here we assume that the WTP function in equation 4 takes the following parametric linear form:

$$WTP_i = \gamma + \varphi p_i + \propto q_i^1 + \partial y_i + \varepsilon_i \tag{5}$$

We rewrite equation 5 assuming that the maximum amount household i is willing to pay for water from the innovative borehole system is posited as WTP_i. The error term is represented as ε_i which follows a normal distribution function with mean zero and standard deviation (σ). In addition to the regressors in equation 5, factors such as gender, marital status, and household decision type of respondent have the potential to explain household's WTP for safe/improved water. Furthermore, these factors are more likely to correlate with income and quantity hence omitting them from the model is likely to lead to omitted variable bias. To ensure consistent and efficiency of the parameters in the WTP function we account for these additional factors in our empirical specification. We specify our explicit a linear functional relationship as

$$WTP_i = \gamma + \varphi p_i + \propto q_i^1 + \partial y_i + \mathbf{X}_i \boldsymbol{\beta} + \varepsilon_i \tag{6}$$

Where $\mathbf{X}$ is a vector of household characteristics, $\boldsymbol{\beta}$ is a vector of parameters to be estimated. All other variables are as already defined.

Hypothetical Market Description

One essential requirement of CVM studies as outlined by the National Oceanic and Atmospheric Administration (NOAA) is a clear description of the hypothetical market. We describe the innovative borehole system which provides the target commodity as:

Hypothetical Market Scenario:

- Stage 1:

  I would want to find out from you, if you value the provision of an improved water supply system in Ghana particularly the rural part of the Greater Accra Region. By improvement it means you are connected to an uninterrupted supply of safe and sufficient water. We have designed an innovative/modernized borehole that is not manual but powered by solar energy so you do not have to pay electricity bills for water generation. This borehole water is filtered, piped and connected directly to your residence. Thus, water flows directly into your residence at all times, the quality is up to acceptable national standards. Generally, we know that every good thing comes at a cost. You may be required to pay a permanent amount that will be factored into your water bills to be provided by the Community Water and Sanitation Agency (CWSA).

- Stage 2 *(Refer to pictorial description for further understanding of oral/written description)*

  In the second stage, a picture representing the scenario described in the first stage was shown and narrated to the respondent (See Fig 1). This is also a preferred approach to just describing a hypothetical market (see Whittington and Pagiola, 2012).

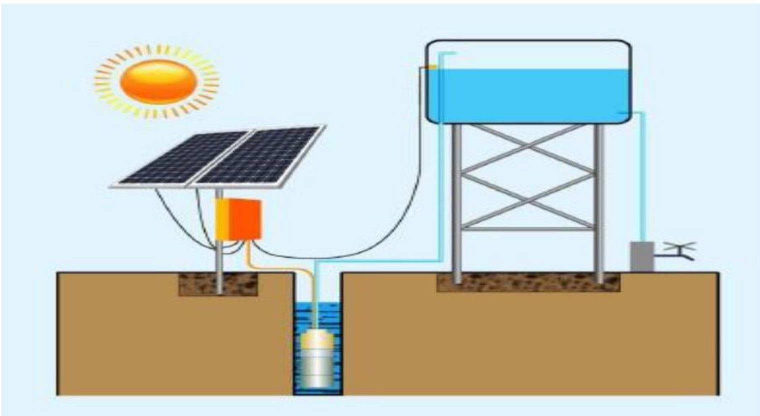

Fig 1: *Pictorial Description of Innovative/Modernized Borehole System.*

In this regard, the two stages were put together and the question asked for the double bound dichotomous choice game was: *"Suppose you are supplied with this innovative/modernized borehole system as orally and pictorially described, how much would you be willing to pay to fetch a 34cm bucket of water from this improved system?"*

Double Bound Approach
The double bound design approach is used in this study. According to Whitehead (2000, p.2), "Estimation of the double-bounded willingness to pay data with the interval data econometric model improves the statistical efficiency of WTP estimates relative to single bound models". However, this approach is prone to starting point and anchoring effect biases. To correct such biases, Bateman et al. (2002) have suggested the use of randomized card sorting procedure (RCS). In this study, we used randomized questionnaire sorting (RQS) procedure which in principle is very similar in approach to the card sorting method. In a nutshell, this study used the dichotomous choice double-bound format with RQS.

Respondents' Bids
We determined marginal WTP through the maximum amount respondents were willing to pay for safe water from the innovative borehole system. The double bound dichotomous choice format used in this study provides three options. A yes or no response data, an interval data and the maximum amount respondents have stated as their WTP for the good in question. Respondents' responses from the WTP question is used as the dependent variable using different model specifications. The OLS uses the final bid amount stated by the respondent. In the case of the interval regression there were four permutations in the responses from respondents. The yes-yes responses, yes-no responses, no-yes responses and no-no responses. This approach is presented in section 3.2.3 (model 2).

3.2.3 Econometric Models Applied

The double bound dichotomous choice format provides midpoints and interval WTP information. We use two econometric models namely OLS and interval regression as robustness checks.

Model 1: The Ordinary Least Squares
In this study, the OLS is applied in both valuation methods namely CVM and HPM. We consider a method in which attention is restricted to the final bid for CVM and monthly rental values for HPM. From a broader perspective, we first consider a multiple regression model, using i subscript to index the cross-sectional observations and "n" to denote the sample size. We represent the multiple regression with $k+1$ parameters and present it as:

$$y_i = \beta_0 + \beta_1 x_{i1} + \beta_2 x_{i2} + \cdots + \beta_k x_{ik} + u_i \qquad i = 1, 2, \dots\dots, n. \tag{5}$$

From equation (2), given our variables of interest to represent some population, we represent y_i as the dependent variable for observation i, and x_{ij}, j=1, 2,...... k, are the independent variables. The intercept is β_0, and $\beta_1, \dots \beta_k$ represent the slope parameters in the model. We rewrite equation (2) in a full matrix notation and define $\mathbf{x}_i$ as a row vector. We represent $\mathbf{y}$ as the $n \times 1$ vector of observations and the i^{th}element of $\mathbf{y}$ as y_i. Also, $\mathbf{X}$ is denoted as the $n \times (k+1)$ vector of observations on the explanatory variables. Thus, the i^{th}row of $\mathbf{X}$ consists of the vector $\mathbf{x}_i$. With u denoting the $n \times 1$ vector of unobservable errors, we rewrite for all n observations as:

$$\mathbf{y} = \mathbf{X\beta} + \mathbf{u} \tag{6}$$

This model assumes u_i to be distributed normally with mean zero and standard deviation σ. Thus, it is in conformity with the Gauss-Markov[6] assumptions underlying the OLS model. This is estimated in both valuation methods used with different functional forms.

[6] For simplified discussions of the Gauss Markov assumptions see Wooldridge (2014, p. 93; 2006)

Model 2: Interval Regression

The interval regression model is presented following the double bound dichotomous choice (DBDC) format of individual's WTP which is generally estimated using maximum likelihood methods (Cameron and Trivedi, 2005). This is achieved by first assuming that the WTP function has a linear functional form and is represented as:

$$WTP_i^* = x_i'\beta + u_i \tag{7}$$

Where WTP_i^* represents the interval within which the true WTP for individual household i can be found. x_i denotes a vector of explanatory variables and u_i a random term which follows a normal distribution function with mean zero and standard deviation (σ).

The DBDC format (see Fig. 2) suggests that there should be a starting bid (b^o). If the respondent says yes, then a second higher bid (b^h) is offered. For this Yes-Yes option, the lower limit is treated as the second higher bid and the upper limit as positive infinity $(+\infty)$. Also, in the case of Yes-No option, the lower limit is the starting bid $(b^o)$and the upper limit is the second higher bid(b^h). However, if the respondent says no to the starting bid, then a second lower bid is offered (b^l). For this No-No option, the upper limit is the second lower bid (b^l) and the lower limit is zero or negative infinity $(-\infty)$. Also, for No-Yes options, the lower limit is the second lower bid (b^l) and the upper limit is the starting bid (b^o) (See Carson et al. 2003).

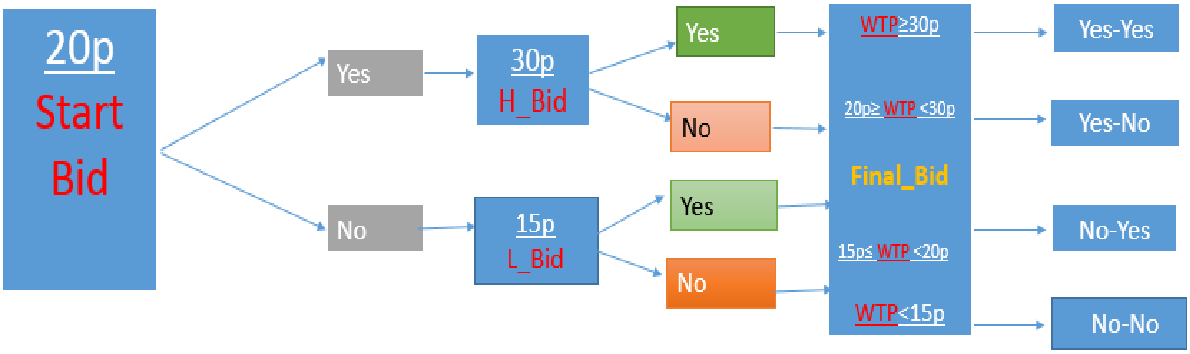

Fig 2: Double Bound Dichotomous Choice Format

The WTP_i^* follows the following definitions. For the:

Yes-Yes option	$WTP_i^* \geq b^h$	i.e. $[b^h - (+\infty)]$
Yes-No option	$b^o \leq WTP_i^* < b^h$	i.e. $[b^o - b^h]$
No-Yes option	$b^l \leq WTP_i^* < b^o$	i.e. $[b^l - b^o]$
No-No option	$WTP_i^* < b^l$	i.e. $[b^l - (-\infty)]$

Taking the cumulative distribution function (CDF) as F, the log likelihood function for the DBDC model is represented in Cameron and Trivedi (2005), and Alberini et al. (1997) as

$$logL = \sum_{i=1}^{n} \log[F(h_i; x_i, \beta, \sigma) - F(l_i\, ; x_i, \beta, \sigma)] \tag{8}$$

Where h_i and l_i are defined as the upper and lower limits or bounds of the interval around WTP. Equation 8 is explicitly formulated and presented for estimation as:

$$wtp_i = f(Y, Age, Male, HH, MS, MSD, R, T, F, Eco, start\_Bid) \quad (9)$$

The explicit interval regression model presented in equation 10, is used as the preferred model because of the following two reasons. First, after controlling for district specific effects and starting point bias, we found no evidence of starting point bias or anchoring effect in our results unlike the OLS models (see Table 3). Second, the interval regression model relative to the OLS estimated in this study, provides the lowest standard errors which suggest a relatively higher level of precision in our estimates. In addition, the parameters in interval regression can be interpreted same way as in an OLS regression. The "Maximum Likelihood (ML) interval technique in log-linear models is unambiguously more reliable than OLS used on interval midpoints" (Cameron and Huppert, 1989, P.242). We therefore transform equation 9 and present it as an interval regression function.

$$lnwtp_i = \beta_0 + \beta_1 lnY_i + \beta_2 Age_i + \beta_3 Male_i + \beta_4 HH_i + \beta_5 MS_i + \beta_6 MSD_i + \beta_7 R + \beta_8 T_i + \beta_9 F_i + \beta_{10} Eco_i + \beta_{11} lnstart\_Bid_i + u_i \quad (10)$$

Where $lnwtp_i$ is a continuous variable that denotes log of the lower bound and upper bound of respondent's WTP per month for safer water from the innovative borehole system respectively, lnY_i is log of household head's take-home monthly income in Ghana cedis, Age_i represents Age in years of respondent, $Male_i$ is a dummy variable representing respondent's gender status, HH_i is the household size of respondent, MS_i is a dummy variable [1, married and 0, unmarried], MSD_i is a dummy variable [1, main reliable source of drinking water is improved source and 0, otherwise], R_i is a dummy variable[1, access to reservoir in respondent's residence and 0, otherwise], T_i is a dummy variable [1, existence/access to toilet facility in respondent's residence and 0, otherwise], F_i is a dummy variable [1, household residence has fence and 0, otherwise], Eco_i is a categorical variable (All the time=1, Sometimes=2, Not at all=3) representing the extent to which respondents use ecologically friendly products. This is used as a proxy to capture respondent's knowledge of environmental issues, $lnstart\_Bid_i$ is log of the starting point bid to test for starting point bias or anchoring effect in the model, and the error term (u_i).

3.2.2 The Hedonic Price Method (HPM)

HPM helps to obtain WTP values through the housing market based on rental values or property sale values and attributes of the property. These attributes are generally presented to include structural characteristics (number of stories, number of rooms, nature of floor space, dwelling age etc.), neighbourhood amenities (distance to public services, distance to work etc.), and environmental amenities (air and water quality or proximity to open space (see Van Den Berg and Nauges, 2012).

The HPM was first formalised by Rosen (1974). This method is based on the perfect competition and perfect observability of attributes assumption. This assumption is inapplicable in heterogeneous markets such as the property market. Again, all attributes are assumed unrelated and individually evaluable. For a simple modelling of the property market, we assume that, how much a household is willing to pay in rental values $(P(Z))$, is conditional on the attributes such as improved source of water in the property. The heterogeneous nature of this market is represented by n attributes. This is presented as:

$$P(Z) = p(z_1, z_2, \ldots . z_n) \quad (1)$$

We denote z_i as measuring amount of i^{th} attribute in the property, Z. The houses in this market are also assumed to be unique intrinsically (e.g. nature of bedroom, number of bedroom, number of bathroom) and extrinsically (e.g. fence or walls, garden etc.). Estimating marginal willingness to pay for an attribute includes determining implicit prices of attributes associated with the good, summing the implicit prices obtained, and multiplying by the measure of the attribute to yield the market price of the good (see Devicienti et al., 2004).

We re-write Z in an explicit form: $\mathrm{Z = S, N, Q}$ (2)
Where **S** represents a vector of structural (or residential) characteristics (access to water in residence(R), access to toilet in residence(T), access to electricity in residence(E), residence with fence (F), number of bathroom facilities(NBF), number of toilet facilities(NTF). **N** denotes a vector of neighbourhood attributes (Water as a district major problem (WDP), distance to nearest hotel or guest or rest house(DNH), distance to commercial transport station(DTS), and $\boldsymbol{Q}$ is neighbourhood socio-economic characteristics (mean district savings (MDS).

In line with Rosen's model, we represent our equations (1&2) as:

$$\mathrm{P(Z) = f(S, N, Q)} \quad (3)$$

Where all variables in equation 3 are as defined. Choumert et al. (2014) argue that simpler functional forms produce more stable parameter estimates, hence this study uses OLS (see model 1 in section 3.2.2) with log-log functional form. We re-write equation (3) following an OLS approach in a more explicit form and specify the econometric model for estimation as:

$$\ln P(Z) = \beta_0 + \beta_1 R + \beta_2 T + \beta_3 AER + \beta_4 F + \beta_5 NBF + \beta_6 NTF + \beta_7 DFI + \beta_8 WDP + \beta_9 DNH + \beta_{10} DTS + \beta_{10} lnQ + u \quad (4)$$

Following the two stage processes of the HPM as presented by Choumert et al. (2014) we determine the implicit marginal price of the different attributes from the aggregate price of the property, $P(Z)$. The partial derivative of the aggregate price function relative to an attribute (z_i), yields the implicit marginal price, p_i, herein referred to as the marginal WTP for the attribute i. In the first stage, we obtain the implicit marginal price by regressing the monthly rental values on the various attributes which include access to improved water supply in residence. In the second stage, we multiply this implicit value by the average house value to yield the marginal WTP for access to improved water supply per month.

4.0 Results and Discussions

We present the descriptive statistics, results and discussions each from the CVM and then the HPM. Also, we attempt to evaluate whether the two competing methods can be compared.

4.1 CVM Results and Discussion

Here, four different models are estimated for the CVM and all results are presented in Table 2. The dependent variable for the: OLS is log of final bid (WTP), interval regression is log of WTP interval (lower and upper limits). The double bound dichotomous choice format provides an interval within a specific range of true WTP. Based on the assumption that respondent's final bid could either be overstated or understated, the interval regression intuitively will provide more information on the Household's WTP relative to the OLS. In addition, as indicated earlier, the interval regression results show no evidence of starting point bias and produced lower standard errors. Therefore, in the CVM, the most preferred model for our study is the interval regression model where the true WTP is assumed to lie within a certain range of monetary values.

In interpreting our results, we ignore the marginal effects as it does not represent the monetary values associated with WTP, and focus on the estimated regression coefficients. Generally, the estimated models (see Table 2) are observed to provide quite consistent estimation results especially with respect to signs of the coefficients across all models. The calculated mean VIF values which range from 1.12 to 1.42 provide evidence of the absence of severe multicollinearity in our models. The goodness of fit (LR chi statistic and R-squared/Pseudo R-squared) support our choice of model 4. All variables to be interpreted assume that "all else are held constant".

Table 1: Descriptive Statistics on variables included in the CVM

Variable	Type	Description	Obs.	Mean [percent]	Std. Dev.	Min	Max	Sign
Household income (Y)	Continuous	Household monthly income in Ghana Cedis (GHC)	583	591.36	655.85	160	4400	+
Age (years)	Continuous	Respondent's Age in years	609	39.31	11.23	21	67	+/-
Male	Dummy	Gender status of respondent	609	0.52	0.50	0	1	+/-
Household size (HH)	Continuous	Household size of respondent	609	4.54	2.28	1	17	+
Marital Status (MS)	Dummy	Marital Status of respondent	609	0.63	0.48	0	1	+
Main Source (MSD)	Dummy	Respondent's main reliable source of drinking water is improved source	553	0.11	0.32	0	1	+
Reservoir (R)	Dummy	Access to water/ reservoir(borehole or well etc.) in residence	609	0.42	0.49	0	1	+
Toilet Access (T)	Dummy	Access to toilet facility in residence	609	0.59	0.49	0	1	+
Fence Access (F)	Dummy	Access to fence in residence	609	0.23	0.42	0	1	+
Eco Product (Eco)	Categorical	Use of ecologically friendly products	609	n/a	n/a	1	3	+
-All the time			229	[37.60%]				
-Sometimes			326	[53.53%]				
-Not at all			54	[8.87%]				
Start Bid	Discrete	Starting point bid	609	25.03 [25% appx][a]	11.24	10	40	+
Lower Limit	Continuous	Lower WTP	609	22.09	11.33	-5	50	n/a
Upper Limit	Continuous	Upper WTP	609	42.40	18.90	10	110	n/a

Mean and Std. Deviation are rounded off to two decimal places. Not Applicable (n/a). [ ] square bracket means figures are reported in percentages. [a]Percent for each of the four bids.

Table 2: CVM Results [with (Yes) and without (No) localization]

	(1)	(2)	(3)	(4)
VARIABLES	OLS (Log-Log)	Interval (Log)	OLS (Log-Log)	Interval (Log)
Household Income (Log)	0.2135***	0.1211***	0.2063***	0.1149***
	(0.030)	(0.020)	(0.031)	(0.021)
Age in Years	-0.0031	-0.0038**	-0.0030	-0.0036**
	(0.002)	(0.002)	(0.002)	(0.002)
Male dummy	0.1045**	0.0587*	0.1313***	0.0770**
	(0.047)	(0.032)	(0.047)	(0.032)
Household Size	0.0099	0.0111*	0.0072	0.0103*
	(0.009)	(0.006)	(0.009)	(0.006)
Marital Status dummy	0.0592	0.0192	0.0685	0.0224
	(0.048)	(0.035)	(0.047)	(0.035)
Main Source of Drinking Water	0.4732***	0.2270***	0.4843***	0.2360***
	(0.079)	(0.053)	(0.075)	(0.049)
Reservoir in Residence dummy	0.0539	0.0171	0.0501	0.0191
	(0.048)	(0.033)	(0.047)	(0.033)
Access to Toilet in Residence dummy	0.0122	0.0796**	0.0093	0.0769**
	(0.046)	(0.033)	(0.048)	(0.033)
Residence Fence-Access dummy	-0.0549	-0.0248	-0.0628	-0.0319
	(0.059)	(0.039)	(0.060)	(0.038)
Use of Eco-product = 2, Sometimes	-0.0451	-0.0161	-0.0642	-0.0252
	(0.051)	(0.036)	(0.051)	(0.036)
Use of Eco-product = 3, Not at all	-0.1425*	-0.1105*	-0.1397*	-0.1057*
	(0.075)	(0.057)	(0.073)	(0.058)
Starting Point Amount (Log)	0.0888**	0.0402	0.0906**	0.0441
	(0.044)	(0.029)	(0.043)	(0.029)
Constant	1.6679***	2.5354***	1.7571***	2.5898***
	(0.220)	(0.159)	(0.215)	(0.156)
District Dummies	***No***	***No***	***Yes***	***Yes***
Observations	521	529	521	529
R-squared[Pseudo R-squared]	0.254	[0.11]	0.294	[0.12]
LR chi(12&18 respectively)		121.11***		136.27***
Mean Variance Inflation Factor(VIF=1/1- R-squared) [a]	1.34	1.12	1.42	1.14

Dependent Variable: WTP, Robust standard errors in parentheses, *** p<0.01, ** p<0.05, * p<0.1, †Exchange Rate (GH¢1=US$0.319 as at 15/10/2014. [a]Pseudo R-squared was used for models 2&4.

We start our discussion with variables capturing the demographic characteristics of respondents. To begin with, the variable *Household monthly income* was found to be positive and highly significant, implying that a one percentage increase in household's income will increase their WTP for safer water supply from the innovative borehole system by 0.1149%. Thus, household's income elasticity is approximately 0.12 with a confidence interval of 0.07 to 0.16. This suggests that the good in question although a normal good, is definitely a necessity. Age was expected to be positive and significant due to experience with different water sources, water use and associated health consequences. However, we found age to be negative and significant. This implies that a one year increase in respondent's age decreases his/her WTP by 0.36%. This suggests that older people are less willing to pay for improved water supply from the innovative borehole system relative to younger respondents. This could be attributed to free rider effect or cohort effect on the part of older people who would expect younger people to pay for them to enjoy. Better still, it may suggest that younger people have different expectation regarding their taste and preferences. This can also be explained by the theory of innovation diffusion where some studies have found that earlier adopters of innovation are younger (Rogers, 1995). Negative effect of age on WTP has also been found by Carson et al. (2001). The variable *Male* was positive and significant. It further shows that males are willing to pay 7.7% more than females in adoption of the new technology. Again, *household size* is found to be positive and marginally significant. Thus, a unit increase in household size, increases WTP for improved water supply from the innovative borehole system by 1.03%. *Marital status* was found to be positive but insignificant.

Next, we discuss variables that are water related. Reliability of the improved main source of drinking water represented as *main source of drinking water* was found to be positive and highly significant. Sachet-water is the main source of drinking water within the study area. An increase in respondent's reliable main drinking water source, increases WTP for safer water supply from the innovative borehole system by approximately 24%. This implies that those respondents who have access to reliable main drinking water source and would still want to have either a safer version or have something similar to what they are used to expressed very high WTP. Stated differently, respondents value what they already have (endowment effect). This inevitable reference point shows how important reliable drinking-water is to the people in rural GAR. *Reservoir in residence* was found to be positive as expected but not significant. *Access to toilet* was positive and significant. An increase in respondent's access to toilet, increases WTP by approximately 7.7%. This implies that those who have access to toilet and know the relevance of reliable water supply in improving their sanitation and health expressed high WTP as compared to those who do not. In other words, higher expectations in improving sanitation through access to safer water supply could explain respondent's WTP. *Residence Fence* determines the extent to which neighbours can easily have access to each other's house. This was found to be negative as expected but not significant.

Furthermore, the degree of environmental knowledge is generally important in determining WTP for a natural/environmental resources. *Use of Eco-product* which is a categorical variable (all the time [reference category], sometimes, and not at all) was introduced to capture the degree of environmental knowledge. One would expect that respondents who are environmentally informed would express a high WTP to access safer water supply from the innovative borehole system due to health concerns. We found that respondents who do not use ecologically friendly products, are approximately 0.11% less WTP relative to those who use ecologically friendly products all the time.

We further introduced log of the starting point amount in the model to capture for possible existence of starting point bias or anchoring effect. We found this to be positive but insignificant in our preferred interval model. This implies that this bias is less important in this model, however, it is important in the OLS model. In short, our preferred model is not being influenced by the randomised starting point amounts used. As shown in Table 3, we proceed to determine the marginal WTP for improved water supply from innovative borehole system per month using the predicted command in Stata 13.

Table 3: Predicted WTP Measures for Reliable & Sufficient water supply from a IBS†

Measures	Max. WTP for a 34 cm bucket of water from a *IBS†* (pesewas)	*[7]Max. WTP reliable & sufficient water from a *IBS†* (Cedis)/Day	[8]**Max. WTP for reliable & sufficient water from a *IBS†* (Cedis)/Month
Mean [95% CI]	29.92 [29.44-30.39]	1.20	35.90 [35.33 - 36.47]
Median [95% CI]	28.88 [28.35-29.36]	1.16	33.50 [32.89-34.06]
% of HH Income [95% CI]		0.20% of mean	6.07% of mean [5.97%-6.17%]

Note: Computation used the Mean Household (HH) Income of 591.36 *and a CI of* [538.01-644.70]. **0.2992×4[9]*
†IBS implies innovative Borehole System.

4.2 HPM Results and Discussion

We now turn to the HPM. We estimate WTP for improved water supply from housing units with current borehole/well system as an attribute using OLS under the assumption that improved water supply has a perfectly inelastic demand in all the districts within the study area.

We first present the summary descriptive statistics of the HPM in Table 4 and the regression results in Table 5. In the latter case, we present four different models. In model 4 (Table 5), the R-squared and the adjusted R-squared are about 32.4% and 30.3% respectively, higher than all the other models. In addition, the mean VIF value of approximately 1.5 for all models show the absence of severe multicollinearity. We admit that the models are different, nonetheless, apart from controlling for district specific heterogeneous effects, the coefficient of variation and the mean VIF values make model 4 our preferred model.

We also observed that all the explanatory variables had the expected signs. However, except for three variables: *Access to toilet in Residence*, *Access to Electricity* and *Distance to Transport Station (KM)*, all estimated coefficients are found to be statistically significant at various levels of significance. In interpreting our variables, we further assume that "all else are held constant".

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[7] **0.2992×4(Buckets). NB:100 pesewas=1GH¢*
[8] ***[0.2992×4(average amount of water required per day per capita)]×30(days)*
[9] The Ministry of Water Resources Works and Housing (1998), and UN(2006) reports average water usage /person/day as about 76 and 75 litres respectively (equivalent of about 4 buckets. NB: 17-18 Litres is equivalent to one 34cm bucket).

Table 4: Descriptive Statistics on variables included in the HPM

Variable	Type	Description	Obs.	Mean	Std. Dev.	Min	Max	Sign
Mean District Savings (Q)	Continuous	Neighbourhood socio-economic characteristics (mean district savings)	609	33.10	10.52	10.28	50.92	+
Transportation (KM)	Continuous	Distance to nearest commercial transport station	576	1.22	5.26	0.005	60	-
Hotel (KM)	Continuous	Distance to nearest hotel	543	6.13	14.84	0.001	120	-
No. of Toilets (NTF)	Continuous	Number of toilet facilities in residence	609	0.74	0.73	0	4	+
Bathrooms (NBR)	Continuous	Number of bathrooms in residence	609	1.36	0.74	1	7	+
District Problem (WDP)	Dummy	Water as district major problem	609	0.79	0.41	0	1	-
Reservoir(R)	Dummy	Access to water/ reservoir(borehole or well etc.) in residence	609	0.42	0.49	0	1	+
Toilet Access (T)	Dummy	Access to toilet facility in residence	609	0.59	0.49	0	1	+
Fence Access (F)	Dummy	Access to fence in residence	609	0.23	0.42	0	1	+
Electricity (E)	Dummy	Access to electricity in residence	609	0.91	0.29	0	1	+
Rent/Month	Continuous	Rental rate per month	609	61.23	42.56	10	200	n/a

Mean and Std. Dev. Are rounded off to two decimal places. Not Applicable (n/a).

Table 5: Hedonic Regression Results [with (Yes) and without (No) localization]

	(1)	**(2)**	**(3)**	**(4)**
VARIABLES	Lnmonth-rent	Lnmonth-rent	Month-rent	Lnmonth-rent
Access to Water in Residence_dum	0.2390***	0.2439***	21.3914***	0.2525***
	(0.048)	(0.048)	(3.741)	(0.047)
Access to Toilet in Residence_dum	0.1221	0.1356*	4.4465	0.1013
	(0.076)	(0.077)	(6.044)	(0.078)
Water as a District Major Problem_dum	-0.1493**	-0.1592***	-10.2999**	-0.1501***
	(0.059)	(0.059)	(4.465)	(0.058)
Access to Electricity_dum	0.0778	0.0744	1.8761	0.0919
	(0.085)	(0.086)	(6.042)	(0.086)
Residence Fence-Type_dum	0.2187***	0.2213***	17.1129***	0.2038***
	(0.059)	(0.059)	(4.875)	(0.060)
Number of Bathroom Facilities	0.0490	0.0441	4.2062	0.0666**
	(0.034)	(0.033)	(2.649)	(0.033)
Number of Toilet Facilities	0.1356**	0.1398**	9.9502**	0.1315**
	(0.056)	(0.056)	(4.951)	(0.059)
Distance to nearest Hotel (KM)	-0.0053***	-0.0055***	-0.4154***	-0.0061***
	(0.001)	(0.001)	(0.095)	(0.001)
Distance to Transport Station (KM)	-0.0052*	-0.0053*	-0.4507*	-0.0025
	(0.003)	(0.003)	(0.232)	(0.003)
Mean_District_Savings	0.0072***			
	(0.002)			
Mean_District_Savings(Log)		0.1266*		
		(0.069)		
Constant	3.3807***	3.1924***	55.3405***	3.8047***
	(0.141)	(0.268)	(8.103)	(0.111)
District Dummies	***No***	***No***	***Yes***	***Yes***
Observations	529	529	529	529
R-squared	0.285	0.277	0.286	0.324
Adjusted R-squared	0.271	0.263	0.264	0.303
Mean Variance Inflation Factor(VIF)	1.49	1.49	1.48	1.48

Dependent Variable: Rent per month in Ghana cedis
Robust standard errors in parentheses
*** p<0.01, ** p<0.05, * p<0.1

Our discussion is presented under water related Residential and Neighbourhood characteristics, other Residential/Structural characteristics, and other Neighbourhood characteristics. The water related explanatory variables presented in our model include: *Reservoir in Residence, Access to toilet facility in Residence, Water as a district major problem.* The other Residential/Structural characteristics include: *Access to Electricity*, *Residence Fence*, *Number of Bathrooms*, *and Number of Toilet Facilities*. Lastly, the other Neighbourhood characteristics include: *Distance to nearest hotel (KM)*, *Distance to Transport Station (KM)* and *Mean_District_Savings*.

In a broader sense of our discussion, the study finds that regarding the water related variables, all of them had the expected a priori signs. To discuss these variables individually, we begin with *Access to Water in Residence* which was proxied with *Reservoir in Residence*. There is a strong evidence that *Access to Water in Residence* has a significantly positive effect on rental values relative to residences without access to water in residence. This is true for all estimated models. The preferred model 4, suggests that houses with *Access to Water in Residence* pay 25.52% more in rent relative to those without. Moreover, *Access to toilet in Residence* is found to be insignificant. This could be attributed to the fact that a lot of people in rural GAR do not have toilets in their residences but rather depend on publicly used and other forms of toilet facilities. Evidence is provided by Apt and Amankrah (2004)[10] who report that 43.5% of households in rural areas of the GAR do not have toilets in their homes. Also, the study provides evidence that the variable *Water as a district major problem* has a negative and highly significant effect on rental values relative to districts within the region with water not as a major problem. Thus, households located in districts with water supply as a major problem pay 15.01% less in rental values relative to districts with water supply not as a major problem.

Next is the Residential/Structural characteristics. The study finds that all the variables in the preferred Model 4 relating to Residential/Structural characteristics had the expected a priori signs (see Sirmans et al. 2005). First, *Access to Electricity* is found to be positive albeit insignificant. This could be explained by the fact that 79% of rural people are without access to electricity in their homes (ibid). Second, *Residence Fence* was introduced to capture possible free-riding effect in areas characterised by communal living. This provides a positive and very high statistically significant effect on rental value. That is, fenced residences pay 20.38% more in rental values relative to unfenced residences. Third, *Number of Bathrooms* had the expected positive sign on rental values. Although this is seen not to be significant in the other models except the preferred model 4. The result suggests that if the number of bathrooms in a residence increase by one, households will pay 6.66% more in rental values. In addition, *Number of Toilets* is positive and significant in all estimated models. It therefore implies that if the number of toilets in residence increase by one, households will pay 13.15% more in rental values. In effect, better residential characteristics evidenced by quantity and quality of residential characteristics are seen to increase rental values.

The quality of neighbourhood characteristics is expected to increase rental values. For example: *Distance to nearest hotel (KM)* which captures some degree of prestige, environmental quality, security, affluence etc. definitely will increase rental values. This variable is seen to provide evidence of a negative and highly statistically significant effect on rental values. This implies that residences that are located within a kilometre range, closer to a hotel, increase rental values by 0.61%. More so, we find *Distance to Transport Station (KM)* variable to be negative and significant in all models except in our preferred model.

To further evaluate the potential effect of district wealth heterogeneity on rental values, we introduced the *Mean_District_Savings* variable models 1&2 as a proxy for income and wealth. This could not have been included in models 3& 4 because of severe collinearity with district dummies. We find evidence of a positive and significant effect of the *Mean_District_Savings* on rental values in both models. It can be inferred that districts with high income and savings (or wealthy households) tend to pay more in rental values. This satisfies the scope sensitivity test commonly found in valuation studies.

We now turn our attention to the computation of the marginal WTP for having access to reliable water supply which is proxied with access to improved water supply in residence. Given that the variable of interest is dummy, we compute the relative change in rental values with results from Table 5 (Model 4) using the delta method. This study finds that the average amount households will be prepared to pay per month for access to water in residence is GH¢ 17.59 which constitutes 2.98% and 2.68% of the mean-district-income and mean-household-income per month respectively (see Table 6). According to Bartik (1988) and Choumert et al. (2014), this should be

[10] Apt and Amankrah (2004): "Assessing Ghanaian Insecurities at the Household Level" ILO Socio-economic Security Programme: Confronting Economic Insecurity in Africa Edited by Rajendra Paratian and Sukti Dasgupta, ILO Office.

interpreted as upper bound values because the utility dummy may include unobserved attributes and utilities.

Table 6: Predicted Increase in the value of house with access to water supply

Marginal implicit house value per month(GH¢)	Current average HH expenditure on water per month (GH¢)	Increment as a % of monthly district-income	Increment as a % of Monthly Household Income
Mean*[11]	Mean	Mean*[12]	Mean*[13]
17.59 [10.34-24.85]	41.554 [39.41-43.69]	2.98% [1.75%-4.20%]	2. 68% [1.58%-3.79%]

[.] Denote confidence intervals estimated at 95%.

4.3 Willingness-to-Pay Estimates: Can we directly compare our estimates?

The CVM and HPM are valuation methods employed to estimate WTP for improved supply of rural water. However, it needs to be pointed out that in application, they could capture different things yet provide relevant estimates that are worthwhile for policy purposes. The estimated results presented in in Tables 3 and 6 are summarised in Table 7. In Table 7, the results are presented in both Ghana Cedis (GHC ¢) and in United States dollars (US$) for easy understanding.

Table 7: A Summary of CVM and HPM Estimates.

Method	**WTP(Gh¢)/M***	**95% CI**	**WTP US$/M***	**% of Income Index**
CVM	35.90	[35.33 - 36.47]	11.45	6.07%
HPM	17.59	[10.34 – 24.85]	5.61	2.68%

*Note: CI denotes Confidence Interval. *M=Month (GH¢=US$0.319 as at 15/10/2014)*

From Table 7, it is important to acknowledge that the CVM used here seeks to measure how much respondents are willing to pay per month for improved and safer water supply from an innovative borehole system. The values captured by this method include use values of an improved system over what is currently being used. In the case of HPM, it seeks to measure the economic value of improved water supply from an amenity (reservoir i.e. traditional borehole or well) in residence per month through house prices, or how much households with access to water are willing to pay per month. Stated differently, the HPM provides estimates of the additional amounts households with access to water supply in residence are willing to pay per month in rental values. This captures only the use values of the current service only. Therefore we expected the CVM to be greater than the HPM. The results show that CVM estimates are much more precise than the HPM at 95% confidence interval.

The HPM estimate of GH¢17.59(US$5.61) per month and the CVM of GH¢35.90 (US$11.45) per month constitute approximately 3%-6% of household income. Paying this by potential beneficiaries represent a sensible trade-off that people might make towards policy implementation (See Carson, 2012). However, it is important to reiterate that these estimates are capturing entirely different things and cannot be directly compared in our case. According to McPhail (1993, p.1), "…most utilities and donors assume that, as long as the cost of potable water to the household falls below 5% of household income, then it is "affordable" and the household will make a connection to the system and be able to pay the subsequent recurrent charges". Similar assertions have also been made by Whittington et al. (1990) to that effect. In view of this, we may conclude that our estimates are within a reasonable range of affordability and that respondents have shown a positive attitude towards the services.

[11] Relative change (water dummy)×Average House Value=0.28724×61.23064=17.59≈Gh¢18 per month
[12] Marginal Implicit house value/Average district- income=17.59/591.3551=0.0298×100=2.98%
[13] Marginal Implicit house value/Average Household income=17.59/655.85=0.0268×100=2.68%

5.0 Policy Implications and Conclusion.

Towards achieving MDG 7(now consolidated into SDG 6), this study focuses on providing information on household's WTP for sustainable, safe rural water supply in Ghana. This study is important against the background that unsustainable planning and management have largely been attributed to absence of information on consumer's WTP for water supply services.

Indeed, policy makers are not fully informed about consumer's WTP to have access to their current state of water supply as well as improvement in water supply. This has triggered a myriad of studies in this area with the primary motive of contributing to policies relevant to sustainable safe water supply. To this end, we use the HPM to capture WTP for the current service, and CVM to also capture WTP for improvement in the service through introduction of an innovative borehole system. We therefore provide policy recommendations as follows:

We recommend that to achieve SDG 6(1) of *safe and affordable drinking water supply,* either an innovative and affordable system with relevance to women and children like this should be considered. Alternatively, the GWCL and CWSA should consider using our estimates for a cost benefit analysis of this project to extend piped water services to the rural areas. Also the estimated WTP may be used to encourage households to adopt such safe appliances across the country and elsewhere.

Currently, the world is full of praise for meeting access to improved water target as enshrined in the MDGs 7. However, we argue following Hunter at al. (2009), and Levisay and Sameth (2006) that not all improved water supply are safe. In order to ensure that the current SDG is achieved with safe water for rural Ghana, this study proposes an innovative borehole system and estimate the demand for water from this system. This is achieved by using the HPM to capture the economic value of an existing system (i.e. marginal WTP for access to improved water from the traditional borehole and well) in residences and CVM to capture the same for improved and safer water from the innovative borehole system. Our results suggest that households support the improvement in their water supply and are willing to pay about 3%-6% of their income.

In short, we present one of the first estimates of the economic values for rural water supply using both the HPM and CVM to capture for current service (*improved water*) and improvement in current service (*safer-water*) through a proposed innovative borehole system in a developing country. These results may be applied to other developing countries with similar characteristics without any loss of generality.

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