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Estimating Demand for Reliable Piped-Water Services in Urban Ghana: An Application of Competing Valuation Approaches.

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JEL classification codes:

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Abstract

This paper applies three valuation methods to estimate demand for reliable piped-water services in Ghana. Our goal is to estimate the economic value of reliable piped-water supply, and use competing methods to provide validity checks for our estimates. We survey 1,648 urban households and find that the average amount that households are willing to pay per month is GHS 44.73 or US$14.27 (Hedonic Price Method), GHS 22.72 or US$7.25 (Travel Cost Method) and GHS 47.80 or US$15.25 (Contingent Valuation Method) respectively. These amounts are equivalent to 3%-8% of households' income. This study provides evidence of the economic viability of private sector involvement in the water sector in Ghana. Our estimates seek to inform both managers and policy makers in their decision-making on reliable piped-water supply.

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1. Introduction

Over the past three decades substantial progress has been made towards global domestic water security. Despite the global success in meeting the 7th Millennium Development Goal[1], several developing countries still suffer from poor water supply problems and the associated consequences. It is estimated that about 780 million people mainly from developing countries are still without access to clean drinking water (Salaam-Blyther, 2012). Ironically, some of these countries have abundant water resources. Ghana, for example, is naturally endowed with a sizeable amount of renewable fresh water for domestic and other uses. The UNICEF and the World Health Organization (UNICEF/WHO, 2012) reports that, an estimated 91% of urban Population in Ghana have access to improved water supply while 33% have piped-water on their premises. This is, however, highly erratic and undependable. Taylor et al. (2002) confirm the erratic nature of water supply, and indicate that less than 10 percent of the population enjoy a reliable in-house potable water connection. Most (87%) of these people are either officials in the public service or high income individuals in the private sector (Owusu and Lundehn, 2006). Water rationing and low quality storage systems, however, leave large portions of the population without adequate potable water (e.g. Stoler et al. 2012).

This situation has since the early 1990s been attributed to high operational costs and low revenue returns (Water Aid, 2005). World Bank (1991), and Brookshire and Whittington (1993) have proposed full cost recovery programmes in the water sector as a way of bridging the cost-revenue gap, in an attempt to solve the supply-deficit gap. They suggest government and donor exclusion but full consumer inclusion in the payment of water supply in Ghana.

However, due to information asymmetry among agents, these suggestions have been disattended. According to Ghana's National Water Policy (2007), one major challenge in the water sector is realistic pricing, the main uncertainty relates to how much consumers would be actually willing to pay for improved water services. This study seeks to fill this informational gap.

This study aims to inform policy making and provide useful guidance for reliable piped-water supply. This is achieved by estimating households' willingness to pay (WTP) and undertaking a cost & benefit analysis for reliable piped-water supply. The choice by researchers on preferred method is sometimes subjective, therefore application of several methods to same choices provide some degree of neutrality (e.g. Carson et al., 1996) and validate estimates.

This study applies and compares three different valuation techniques, namely the Hedonic Price Method (HPM), the Travel Cost Method (TC) and the Contingent Valuation Method (CVM), to estimate the WTP for a reliable piped-water supply. Thus, the main contribution of this paper is its application of three independent valuation methods to provide robust estimates of the WTP to inform policy. The estimates seek to bridge the information asymmetry gap in this market by providing evidence for investment opportunities in the water sector. In line with providing information to inform policy, we find WTP to constitute 3-8% of households' income. In addition, our cost & benefit analysis show a positive net benefit for investing in reliable piped-water supply in Ghana. Our results is consistent with existing studies on WTP for piped-water as seen in the literature such as Van Den Berg and Nauges (2012), and Choumert (2014b).

The rest of this study is structured as follows: A description of the methodological framework used in the study is presented in section 2. Section 3 presents how data was collected and econometric modelling of the valuation methods used. The analysis and discussion of results are presented in section 4. Section 5 presents the conclusion of the paper.

[1] To halve, by 2015, the proportion of the population without sustainable access to safe drinking water and basic sanitation. Currently, more than 2.1 billion people have gained access to improved drinking water sources since 1990, exceeding the MDG target (88%) by 1%. This makes 6.1 billion (89%) having access to improved drinking water sources (see UN Dept. of Public Information, September 2013).

2.0 Methodological Framework

3.1 The Hedonic Price Method (HPM)

In an attempt to put values on non-market goods unlike market goods, the HPM is used as an indirect valuation method for non-market goods which follows the revealed preference (RP) theory. The basic intuition of this approach is that a house is fully characterised by its attributes (structural, neighbourhood and environmental), and that price differentials reflect the values associated with the different attributes of the house. Thus, the valuation of piped-water is based on the presumption that rental values of a house is a function of the house's attributes which include piped-water. This relationship has it's foundations in the consumer demand theory. Following Birr-Pedersen (2008), Zabel (2004), Day (2001) and Sheppard (1999), we assume a rational household with a fixed income, M, and the price function P($\mathbf{z}$) that obtains utility by consuming vector $\mathbf{z}$ of different attributes, plus consumption of a composite good x which is normalised to take a unit price of one. These vectors explain variations in household preferences. This expression can be presented by the utility function:

$$\mathrm{u_i} = \mathrm{u}(\mathbf{z}, \mathrm{x}, \boldsymbol{\alpha}) \tag{1}$$

Thus, the household's level of utility is conditioned on the vector $(\boldsymbol{\alpha})$. Where $\boldsymbol{\alpha}$ is a vector parameter captured in the model to explain both observable and unobservable household characteristics. We further assume that a household faces a static setting in preferences which is conditioned on his budget constraint. The household maximises utility subject to his budget constraint specified as equation (2):

$$\max_{\mathbf{z},\mathbf{x}}: \mathrm{u}(\mathbf{z}, \mathrm{x}; \boldsymbol{\alpha}) \quad \mathrm{s.t} \quad \mathrm{P}(\mathbf{z}) + \mathrm{x} \leq \mathrm{M} \tag{2}$$

$$\mathrm{L} = \mathrm{u}(\mathrm{z}, \mathrm{x}, \alpha) + \lambda\big(\mathrm{M} - \mathrm{x} - \mathrm{P}(\mathbf{z})\big) \tag{3}$$

We obtain equation 4 which shows the implicit price function or implicit marginal price for the property attribute $\mathrm{z_i}$ by taking the partial derivative of equation 3

$$\mathrm{P}(\mathbf{z}_\mathrm{i}) = \frac{\partial \mathrm{P}}{\partial \mathrm{z_i}} \tag{4}$$

This method was formalised by Rosen (1974). He assumes perfect competition and perfect observability of attributes. However, this assumption is not applicable in this study considering the fact that the property market is heterogeneous. We consider a property market that is described by n attributes,

$$\mathrm{P}(\mathbf{z}_\mathrm{i}) = \mathrm{P}\big(\mathrm{z_1}, \mathrm{z_{2,}} \ldots\ldots \mathrm{z_n}\big), \tag{5}$$

and denote $\mathbf{z}_i$ as measuring amount of i^{th} attribute in the property, $\mathbf{z}$. The houses in this market are assumed to be unique intrinsically and extrinsically. Two stages can be applied in determining the marginal willingness to pay for an attribute. First, determine implicit prices of attributes associated with the good, and then the summation of the implicit prices, multiplied by the measure of the attribute will equal the market price of the good (see Amoah, 2017., Choumert et al., 2014b; Devicienti et al., 2004). In our case, we generate the implicit marginal price by regressing the monthly rental values on the various attributes which include access to reliable piped-water supply in residence. Then in the second stage, we multiply this implicit value by the average house value to yield the marginal willingness-to-pay for reliable piped-water supply in residences.

3.2 The Travel Cost Method (TCM)

As in the case of the HPM, TCM is also an observed indirect non-market valuation method which follows the RP theory. This method is recognised in literature as the oldest method of all non-market economic valuation methods. It mainly uses consumption behaviour in related markets to determine economic values (Fleming and Cook, 2008). In spite of its shortcomings, Smith (1993, p.3), still recognises it as "…one of the 'success stories' of nonmarket valuation and occupies a major place in the applied research programmes of resource and environmental economists". This has been explained by Zandersen (2005) as being the case because estimates are generally consistent with consumer demand theory. She further argued that TCM offers a utility consistent and robust methodology which explains factors that significantly explain variance in valuation outcomes.

Given individual household's income, $\mathrm{M_i}$, the i^{th} individual household chooses V_{ij} round-trips to haul for water assuming a single location or site at a travel cost $\mathrm{C_{ij}}$. The individual household's utility function can be expressed as

$$\mathrm{U_i} = \mathrm{u}\left(\mathrm{V_{ij}}\,,\mathrm{z_i}\right) \tag{6}$$

Where z is described as the Hicksian composite good. Here we assume that the location household's travel to haul for water is separable from all other locations. The individual household maximises utility subject to his budget constraint specified as equation (7):

$$\max_{\mathrm{V,z}}: \mathrm{u}\left(V_{ij}\,,\mathrm{z_i}\right)\ \text{s.t.}\quad \mathrm{C_{ij}}V_{ij}\ + \mathrm{z} \leq \mathrm{M_i} \tag{7}$$

In the words of Garrod and Willis (1999, p.55), TCM is usually estimated as a trip generating function. This is simply presented as:

$$V_{ij}\ = f\ (C_{ij}, \boldsymbol{S_j}) \tag{8}$$

From equation 8, V_{ij} is the number of round-trips made by individual household i to site j, C_{ij} is the travel cost incurred by individual household i when visiting site j and $\boldsymbol{S}_{\mathrm{j}}$ is a vector of travel cost to available substitute sites. This function is presented by Garrod and Willis (1999) and Bateman (1993) in two main forms namely the Zonal Travel Cost Method (ZTCM) and the Individual Travel Cost Method (ITCM). By way of comparison, according to Garrod and Willis (1999), the ITCM is observed to have a distinct advantage over the ZTCM in that while the latter depends on zonal aggregate data which does not take into account inherent variation in the data, the former does. Moreover, the ITCM is regarded to be statistically more efficient.

We focus on the ITCM which allows the specification of a number of individual (household)-specific explanatory variables. This is modelled as:

$$V_{ij} = f\ (C_{ij}, T_{ij}\ \boldsymbol{X_j}, \boldsymbol{S}_{j,} \boldsymbol{Q_i}) \tag{9}$$

With reference to equation 9, T_{ij} is the time cost incurred by individual household i when visiting site j; $\boldsymbol{X_j}$ is a vector of the perceived qualities of the site j; $\boldsymbol{Q_n}$ is a vector of socioeconomic characteristics of individual household i. All other definitions remain the same.

3.3 The Contingent Valuation Method (CVM)

The CVM which is a stated preference (SP) method is considered as a very useful technique commonly used. This method follows the idea that individual's behaviours are observed as they provide responses to hypothetical questions. The theoretical basis for such an approach to valuing environmental assets relies on microeconomic welfare theory where individuals or households maximize their utility under income constraint, or minimize their expenditure under utility constraint (Spash, 2008; Hanley and Spash, 1993).

We simplify the theoretical framework of the CVM as similar to Amoah (2017), Irvin (2007), and Whitehead & Blomquist (2006). Here, we specify a standard consumer's utility maximization function subject to income and prices as:

$$\max_{x,q}\ U(x,q) \qquad s.t.\ \ y = q + px \tag{10}$$

Where y denotes the income of respondent, q is a composite of all other goods and services, p and x are the marginal price and quantity of piped-water respectively. From the maximisation problem specified in equation 10, we obtain the indirect utility function as:

$$v(p,y) = \max_{x,q}\{U(x,q)|px + q = y\} \tag{11}$$

We specify the respondents WTP as a proportion of his income spent on reliable piped-water. We show the reliable piped-water as an increment in respondent's expenditure, $x^1 > x$. This is presented in equation 12.

$$v(p,x,y) = v(p,x^1,y - WTP) \tag{12}$$

The respondent's utility is assumed to change from u^0 to u^1 which we show as

$$u^0 = v(p,x,y) < u^1 = v(p,x^1,y) \tag{13}$$

The inverted utility maximisation is expenditure minimisation, so we specify the expenditure function as:

$$e(p,u) = \min_{x,q}\{px + q \mid u^1(q,x^1) > u^0(q,x^0)\}$$

WTP is shown as the difference between the expenditure functions specified as equation 14.

$$WTP = e\big(p,x,v(p,x,y)\big) - e(p,x^1,v(p,x^1,y)) \tag{14}$$

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

$$CS(x,x^1) = WTP = e(p,x^1,v(p,x^1,y)) - y \tag{15}$$

Equation 15 (compensating surplus function) represents a measure of WTP for the reliable piped-water as a function of quantity of water 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 15 into an econometric function. Here we assume that the WTP function in equation 15 takes the following parametric linear form:

$$WTP_i = \gamma + \varphi p_i + \propto q_i^1 + \partial y_i + \varepsilon_i \tag{16}$$

We rewrite equation 16 assuming that the maximum amount household i is willing to pay for reliable piped-water 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 15, factors such as fence type, number of households, other family members (family size), age, age squared, knowledge of local and international environmental issues have the potential to explain household's WTP for reliable piped-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:

$$WTP_i = \gamma + \varphi p_i + \propto q_i^1 + \partial y_i + \mathbf{X}_i\boldsymbol{\beta} + \varepsilon_i \tag{17}$$

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

From the theoretical point of view we expect the CVM which captures both use and non-use values to be greater than the HPM and TCM methods which captures on use values. In short, we expect the SP method to be greater than the RP methods.

3.0 Data and Econometric Modelling of Valuation Methods

3.1 Data

The study focuses on the Greater Accra Region (GAR) of Ghana on grounds that it is one of the hardest hit regions regarding acute water shortages and has since 1970s dominated in the percentage increase in the share of households[2]. This region has the current highest proportion of urban household of 31.2%. Moreover, GAR has Accra as its capital city and has been Ghana's capital since 1877. It has the highest population density and is the second most populous region in Ghana. It is also seen as one of the most populated and fastest growing Metropolis in Africa (AMA, 2006)[3]. GAR is made up of Metropolitan/Municipal and/or District Assemblies. Until recently that new districts[4] were created, it consisted of ten administrative regions. According to the 2010 Housing and Population Census (GSS, 2012), the total population of the GAR with ten districts is 4,010,054. The population in households is 3,888,512 with male and female distributions as 1,938,225 and 2,071,829 respectively. The total number of households is 1,036,426 with an urban household population of 766,955 and a rural household population of 269,471. Since this study focuses on the urban household, the reference population is represented by the 766,955 urban households.

This study used a sample size of 1,650 household heads who were interviewed in the survey using a questionnaire. The study designed a structured questionnaire which included the personal data of the respondent, besides general water, sanitation and environmental questions; hedonic valuation questions, travel cost questions; and contingent valuation questions. The questionnaires were administered by 20 fieldworkers and 4 coordinators under an overall supervision. They were first trained, and were made to undertake a pre-pilot survey before the actual pilot survey so as to build their experience with this questionnaire. The data was collected between March and May, 2014. This period represents a balanced season for the South, so we do not expect the seasons to influence our data.

The in-person survey method which has been described as the method of choice in surveys by Mitchel and Carson (1988) was used to control for sampling problems and low response rate associated with telephone and mail surveys. Mitchel and Carson (1988) suggest that after a properly defined population, one important factor that can affect the generalisation of results is how the sampling frame is structured. The sampling frame was mainly housing units within each district. The district should be one of the ten districts in the GAR to ensure sufficient geographical coverage and spatial variation. The unit of analysis were household level respondents mainly household heads who are 18years and above, and of sound mind. They should have worked within the last five years and are currently employed or unemployed within the last seven days of the month of the interview. They should be living in the district and not be visitors. All potential respondents reserved the right to either accept to participate or decline participation.

One problem observed in valuation studies is the intra-household allocation issues (see Whittington and Pagiola, 2012; Prabhu, 2010; Whittington et al., 2008; and Adamowicz et al., 2005). To control for intra-household allocation issues, the simplest recommended approach is to consider the entire household as the sampling unit but interview whoever the household considers as the household head or decision maker (Whittington and Pagiola, 2012). This they argue could either be the husband or the wife. However, in the cooperative bargaining case, this approach would be inadequate. In this study, the interviewers were made to find out who the head of the household was. The head was described as prescribed by the GSS (2012) as one who is economically and socially responsible for the entire household. In the event of cooperative

[2] 1970-1984 stood at 66.9%, 1984-2000 also stood at 74.6%, and 2000-2010 recorded 65.4%. (Source GSS, 2012 P.71)
[3] Accra Metropolitan Assembly (AMA, 2006) accessed @http://ama.ghanadistricts.gov.gh on 01/05/2016.
[4] The new districts as of the time of the study was constrained by complete population and household data. Therefore the data as of the last population census was used for this study.

bargaining, the interviewers asked who bears the majority of the household water cost and decision. Such a person was interviewed in this case.

A valid application of valuation methods require an appropriate sampling survey technique. In the event of unplanned settlements, some researchers are therefore forced to use a smaller sample (see Whittington, 1998) which perhaps may not be representative enough. It is widely known that inappropriate sampling technique could lead to biased estimates. However, with the unplanned settlements in urban GAR, a multistage quota sampling technique was applied (see Whittington, 1998). This was achieved by clustering the region into ten districts, then into their respective communities. Then 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. 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 1,650 from the population.

3.2 Econometric Modelling of Valuation Methods

3.2.1 The Hedonic Price Method (HPM)

Following the methodological framework and the econometric proposition by Rosen (1974) in equation 5, the proposed model for HPM is stated as:

$$P(\mathrm{Z}) = \mathrm{P}(\mathrm{S}, \mathrm{N}, \mathrm{Q}) \tag{16}$$

$$\mathrm{Z} = \mathrm{f}(\mathrm{S}, \mathrm{N}, \mathrm{Q}) \tag{17}$$

Where dependent variable is the rental rate, $P(\mathrm{Z})$, **S** represents a vector of structural (or residential) characteristics, **N** denotes a vector of neighbourhood attributes /accessibility variables, and Q is neighbourhood socio-economic characteristics. **S** include access to reliable piped-water supply in residence(ARP), access to toilet facility in residence(T), access to installed water reservoir in residence(R), number of garages(G), and number of storeroom(S). The a priori expectation of the effects of these variables on rental rates are all positive. Thus, higher valued structural characteristics should influence rent values positively. **N** which is also a vector of the Neighbourhood or accessibility characteristics include distance to highway(DH), distance to financial institution (DFI), and distance to school (DS). More public neighbourhood characteristics should influence rent values positively. However, neighbourhood characteristics associated with negative externalities are expected to be negative on rent values.

The economic literature has provided little theoretical guidance on the specific functional forms of hedonic pricing and housing characteristics (Lisi, 2013; Malpezzi, 2003; Taylor, 2003). Halvorsen and Pollakowski (1981) proposed a flexible functional form commonly used in empirical studies known as the Box-cox function. This however has been made unpopular by the likes of Cassel and Mendelsohn, 1985; Cropper et al., 1988, Sheppard, 1999; Choumert et al., 2014b. Their justification is based on the sensitivity of the data to small variations and difficulty in interpreting parameter estimates. Following Choumert et al. (2014b) who argue that simpler functional forms produce more stable parameter estimates, this study uses ordinary least squares with a log-log functional forms. We re-write equation (16) in a more explicit form and specify our preferred log-lin econometric model as equation 18. We tweak it to include a proxy for wealth as shown in equation 19 and present results in model (1&3[see Table 1]).

$$lnP(Z) = \beta_0 + \beta_1 ARP + \beta_2 T + \beta_3 R + \beta_4 G + \beta_5 S + \beta_6 DH + \beta_7 DFI + \beta_8 DS + \beta_9 \mathrm{Dum} + u \tag{18}$$

$$lnP(Z) = \beta_0 + \beta_1 ARP + \beta_2 T + \beta_3 R + \beta_4 G + \beta_5 S + \beta_6 DH + \beta_7 DFI + \beta_8 DS + \beta_9 \mathrm{lnQ} + u \tag{19}$$

3.2.2 The Travel Cost Method (TCM)

The most common model employed for travel cost estimation is the single-sight model (Parsons, 2003). This is a demand model that seeks to estimate number of trips by a household to say a source of water supply over a period of time. Since demand is expressed as quantity demanded over price, the quantity demanded is represented by the number of trips a household make to the source of water supply. The price is also represented by cost per trip in reaching the source of water supply. Generally one would expect an inverse relationship between these two variables as in the case of its analogous demand form. In line with Parsons (2003), we simplify equation 15 to have a simplest form of a single sight model which takes the form:

$$\mathrm{V_i} = \mathrm{f}(\mathrm{C_i}, \mathbf{Z}_\mathrm{i}) \tag{20}$$

Where V_i is the number of round-trips made by individual households over a period of time to the source of water supply. C_i is the cost of the round-trips made by individual households, $\mathbf{Z}_i$ is a vector of households' socio-economic and demographic characteristics. Based on equation 20, we extend the simplest form of a single-sight model and present the estimated non-linear model as:

$$\mathrm{V_i} = (\mathrm{lnCM_i}, \mathrm{lnCO_i}, \mathrm{ARP_i}, R_i, \mathrm{OFM}_i, \mathrm{lnY_i}, \mathrm{S_i}) \tag{21}$$

Where CM_i is the amount it cost per round-trip for an individual household to visit the main source of water supply. We expect this to be negative. CO_i is also the cost per round-trip for an individual household to access other sources of water supply which accounts for substitution effect. This is expected to be positively related to T_i. APR_i denotes household access to reliable piped-water in residence, R_i represents household alternative source of water supply in residence such as boreholes and wells is captured as reservoir in residence, OFM_i is the other family members in household, Y_i represents monthly income of the household, and S_i is household savings.

As in the case of the HPM discussed earlier, economic theory is not emphatic on the exact theoretical and appropriate functional form of travel cost models. However, it is important to note that in the case of the non-negative integer feature of round-trip or count data, truncation of data at zero visits, and some over-dispersion problems OLS is inappropriate and should be replaced by procedures such as maximum (ML) estimation (Shrestha et al., 2002; Bateman 1993). It is against this background that studies (such as Creel and Loomis, 1990; Hellerstein, 1991; Feather et al., 1995; Hausman et al., 1995, Englin and Shonkwiler, 1995; Grogger and Carson, 1991; Cameron and Trivedi, 1998; Winkelmann, 2000; Shrestha et al., 2002; Ahmad, 2009) have used count data ML estimation techniques models such as Poisson and Negative Binomial. From Haab and McConnel (2002) we present the Poisson probability and Negative Binomial probability Models as:

Poisson probability Model

$$P_{r(v)} = \frac{e^{-\lambda}\lambda^{v}}{v!}, \qquad v = 0, 1, 2 \dots \dots \tag{21a}$$

Here we denote v as non-negative integer outcome and λ as the Poisson mean.

Negative Binomial probability Model

$$P_{r(v)} = \frac{\Gamma\left(v+\frac{1}{\alpha}\right)}{\Gamma(v+1)\Gamma\left(\frac{1}{\alpha}\right)}\left(\frac{\frac{1}{\alpha}}{\frac{1}{\alpha}+\lambda}\right)^{\frac{1}{\alpha}}\left(\frac{\lambda}{\frac{1}{\alpha}+\lambda}\right)^{v} \tag{21b}$$

The Negative binomial model assumes that the conditional mean and the variance are different. So, as alpha α approaches zero (0), the distribution collapses to the Poisson probability distribution.

We therefore estimate the OLS and Poisson models together with the Negative Binomial model. However, because of evidence of over-dispersion, we use OLS and Poisson models for robustness checks and focus our discussions on the Negative binomial model.

3.2.3 The Contingent Valuation Method (CVM)

We simplify equation 15 following Whittington et al. (1990a) and assume that the maximum amount an individual household (i) is willing to pay for a proposed service is given as WTP_i. Given the traditional consumer theory which suggests a relationship between price and quantity demanded or supplied, we presume a linear functional relationship between WTP_i and household's characteristics and attributes of the water sources. This is specified as:

$$WTP_i = \alpha + \mathbf{X}_i \boldsymbol{\beta} + u_i \tag{22}$$

Where $\mathbf{X}_i$ is a vector of household's characteristics and attributes of the water sources, α and $\boldsymbol{\beta}$ are parameters of the model, u_i is the error term with a standard normal distribution. To determine WTP, first The NOAA Panel Guidelines requires an "Accurate Description of the Program or Policy" or [Project] and for "adequate information" to be provided to respondents about the program being offered (Arrow et al. 1993, p.10). In this case, NOAA requires an accurate description of the (hypothetical) market.

Hypothetical Market Description of Commodity

- As part of the guidelines prescribed by NOAA in CV studies, (hypothetical) market description is one essential key that cannot be underestimated. In a simplified context, our market is an imaginary situation respondents are asked to demonstrate what they think they will do assuming they are behaving rationally. In this study, we describe the piped-water services that could be made available to households and their corresponding market values. An estimation of the demand for piped water system is contingent upon the existence of our described market. Thus, households' WTP responses are based on how the market was described. The (hypothetical) market was to urge households to reveal their maximum WTP for an uninterrupted (reliable) pipe water system. This study describes the target commodity to the household in a market-like situation in two phases: first, "*I would want to find out from you, if you value the provision of an improved water supply system in Ghana particularly in the Greater Accra Region. By improvement we mean you are connected to the Ghana Water Company Limited (GWCL) main lines, water flows directly in your residence at all times, and the quality of the water is up to an acceptable international standard…"* In the second phase, *a picture representing the scenario described in the first phase was shown and narrated to the respondent.*

This is also a preferred approach to describing a hypothetical market. Its implementation is to use visual aids such as pictures, maps, diagrams, figures, and tables (see Whittington and Pagiola, 2012; Labao et al., 2008; Boyle, 2003, 1989; Ahearn, et al., 2003). This helps the respondent especially in areas where the illiteracy level is quite high to appreciate the CV scenario being described. The clearer the market description the better position the buyer could express his preference. Whittington and Pagiola (2012) have argued that the use of visual aids during presentation of hypothetical CV market scenarios is an indicator of a high-quality CV study.

In this regard, the two phases were put together and the question asked for the double bound dichotomous choice game was: *"Generally, we know that every good thing comes at a cost and you may be required to pay a permanent amount that will be factored into your water bills provided by GWCL. Suppose you are supplied with an uninterrupted (reliable) piped-water as orally and pictorially described, how much would you be willing to pay to fetch a 34cm bucket of water?"*

Bidding Mechanisms

There are several bidding mechanisms or elicitation mechanisms used in survey studies for determining willingness to pay. These include bidding game format, payment card, open ended question, close ended question, single-bounded referendum, double-bounded referendum, and triple-bounded referendum.

The double bound design approach (Carson et al., 1986; Carson and Mitchell, 1987; Welsh and Bishop, 1993) is used in this study. To control for possible starting point and anchoring effect biases, Bateman et al. (2002) have suggested the use of randomized card sorting procedure (RCS). This was modified and we used randomized questionnaire sorting (RQS) procedure which applies the same principle as the card. The only difference is that one uses questionnaires while the other uses cards yet all are randomized to achieve the same purpose. In sum, this study used the dichotomous choice double-bound format with RQS.

Obtaining Respondent's Bid

Against the background that Ghana is a developing country, it was prudent to control for large number of non-responses which could arise if the study had adopted interactive computer medium, mail questionnaire with follow ups, and telephone interview as a result of illiteracy and incidence of poverty rates. The in-person or face-to-face approach was used by this study because it provides a stronger engagement with respondents which has the advantage of reducing questionnaire misunderstanding and making spontaneous questions and answers possible.

In obtaining bids, WTP is determined when an individual in the household herein the household head who represents the entire household indicates through a bidding mechanism the maximum amount he/she is willing to pay for a reliable piped water services. The double bound dichotomous choice format used in this study provides two options. A yes/no response data, an interval data and the maximum amount respondents state on how much they are willing to pay.

Responses from this question were used as the dependent variable subject to the model type. The Ordinary Least Squares (OLS: log-log) uses the open ended final WTP amount stated by the respondent. For the Ordered Probit (Oprobit), the final WTP values were ordered into four different categories. In the case of the Interval Regression (Interval) there were four different expectations from respondents' responses. The yes-yes responses, yes-no responses, no-yes responses and no-no responses. Where the option yes-yes was given by the respondent, the upper limit is positive infinity and the lower limit is the second higher bid. In case of yes-no option, the upper limit is the second higher bid and the first bid the lower limit. For no-yes options, the upper limit is the first bid and the second lower bid was the lower limit. In the last no-no options, the upper limit is the second lower bid given and the lower limit is negative infinity (see Carson et al. 2003; Krishna et al. 2013). Equation 22 is explicitly formulated and presented for estimation as:

$$lnWTP_i = \beta_0 + \beta_1 MSD_i + \beta_2 MSGU_i + \beta_3 E_i + \beta_4 F_i + \beta_5 NHH_i + \beta_6 OFM_i + \beta_7 lnY_i + \beta_8 Age_i + \beta_9 Age_i^2 + \beta_{10} KL_i + \beta_{11} KI_i + \beta_{12} lnBid_i + u_i \tag{23}$$

Where MSD_i is households' reliable main current source of water for drinking, $MSGU_i$ is households' reliable main current source of water for general use, E_i is average households' expenditure on current water sources per month, F_i household residence fence type, NHH_i is number of households in residence, OFM_i is Other family members in the household, Y_i is household heads' income, Age and Age squared in years of respondent are denoted as Age_i and Age_i^2 , KL_i is knowledge of domestic or local environmental issues, KI_i is knowledge of international environmental issues, Bid_i is the starting point bid/amount, and the error term (u_i).

3.3 Descriptive Statistics

The average rent paid by households the last month before the survey and used for the study was GHS 138.23, with the minimum rent being GHS10 and the maximum being GHS1000. The mean district monthly take-home income was GHS 636.18, not too different from the household take-home income of GHS636.37. Both are quite close to the national estimate of GHS544 for the GAR (GSS, 2008). The average rental value constitutes 22% of the district income. We described reliable piped-water supply as those who have daily supply of piped-water (except for technical fault). About 29% of respondents have access to reliable piped-water supply providing evidence of severity of access to piped-water in Ghana. Also, about 91% do not have access to garage facilities in their homes followed by about 7% having at least a garage and the rest having about two or three garages in their residence. A significant fraction constituting over 72% have access to toilet facilities while over 52% do not have access to reservoirs (such as wells and boreholes) in their residences. This supports the rationale for households demanding reliable supply of water in residences. The average distance from residences to the nearest highway, financial institution and school were 0.65km, 0.67km, 0.25km respectively.

Households make an average of approximately 100 round-trips to their main water sources per month. This constitutes an average of three round-trips per day. About 83% have other family members staying with them. This reflects the communal living nature of the study area. The average age of respondents was about 39 years. It cost household GHS 9.16 per round-trip to main source of water supply and GHS 55.52 per round-trip to other sources of water supply. The responses to the question on who bears household hauling burden revealed that about 48% of the burden on water lies heavily on children. The mean WTP for a 34cm bucket of water from piped-water sources in residence is approximately GHS 0.40 which is greater than the average GHS 0.35 they currently pay in GAR. The ordered responses had approximately 52% of the respondents were WTP GHS 0.20, 43% were WTP GHS 0.30, then about 4% and 1% were WTP GHS 0.40 and GHS 0.50 respectively. With the interval WTP responses, we observed that the lower WTP amounts and the upper WTP amounts recorded averages of about GHS 0.32 and approximately GHS 0.53. The starting point bid were in four discrete values: 0.20, 0.30, 0.40, and 0.50 (all in GHS). The number of average households in a house was about 5. About 97% and 75% affirmed that their main source of drinking water and water for general use is not reliable. Average expenditure by households per month on water was about GHS 52.22. This constitutes approximately 8% of households take-home income which is almost within the approximately 3%-8% estimated by this study. About 59% of houses had fence. Lastly, Respondents who had knowledge about local and international environmental issues comprises of 55% and 61% respectively.

4.0 Results

This section presents the results from the three valuation approaches employed in this study.

4.1 Hedonic Price Valuation Results

Our estimated regression results which follows different functional forms are presented in Table 1. All the models are estimated with robust standard errors. Our preferred model is model 4 because it reports the highest coefficient of variation of approximately 18%, and a relatively lower AIC test value of 3,584.166. More so, it is estimated with district dummies which allows for differences in the average level across districts in addition to adjusting the standard errors to take into account specific intra-group correlations. This helps to control for unobserved heterogeneity making it much more likely that the coefficients of the variables do change across districts (see Englin and Cameron, 1996). For robustness purposes, we observe that all the variables, irrespective of model, kept their respective signs with marginal changes in some of their significance levels as well as their coefficients. The variance inflation factor (VIF) is used to test for the severity of multicollinearity in the models. The Mean VIF of 1.12 is even not significantly greater than 1 hence we can conclude that multicollinearity is not a serious problem in these models shown in Table 1.

Table 1: Hedonic Regression Results [with and without localization]

VARIABLES	(1) Lin-Log	(2) Lin-Lin	(3) Log-Log	(4) Log-Lin
Access to Rel. Piped Water in Residence	37.7175***	35.1151***	0.2946***	0.2803***
	(10.619)	(10.990)	(0.058)	(0.059)
Access to Toilet Fac. in Residence	52.1381***	56.2479***	0.5017***	0.5174***
	(8.156)	(8.253)	(0.051)	(0.051)
Reservoir in Residence	29.0835***	22.9241***	0.1996***	0.1744***
	(8.890)	(8.840)	(0.049)	(0.050)
Number of Garage	52.4993***	47.9972**	0.2477**	0.2315**
	(19.715)	(19.895)	(0.096)	(0.097)
Number of Storeroom	37.2483***	36.8579***	0.1878***	0.1874***
	(13.067)	(13.021)	(0.068)	(0.068)
Distance to Highway (Km)	-4.9820***	-5.1941***	-0.0272***	-0.0301***
	(1.461)	(1.487)	(0.010)	(0.010)
Distance to Financial Institution (Km)	-8.1965**	-7.9263*	-0.0276	-0.0317
	(4.136)	(4.124)	(0.031)	(0.030)
Distance to School (Km)	-20.4648***	-16.9776**	-0.1129**	-0.0992**
	(7.083)	(7.089)	(0.046)	(0.046)
Mean District Income (Log)	90.8318***	N/A	0.5253***	N/A
	(30.116)	-	(0.168)	-
Constant	-512.4415***	69.9812***	0.4304	3.8304***
	(191.040)	(9.442)	(1.069)	(0.057)
District Dummies	*No*	*Yes*	*No*	*Yes*
Observations	1,375	1,375	1,375	1,375
R-squared	0.114	0.130	0.167	0.177
Adjusted R-squared	0.108	0.120	0.162	0.167
Akaike Information Criterion (AIC)	17,923.42	17,911.98	3,585.99	3,584.166
Mean Variance Inflation Factor (VIF)	1.12	1.12	1.12	1.12

Dependent Variable: Rent per month in Ghana cedis (1GHS= 0.319 US$ as at 15/10/2014)
Robust standard errors in parentheses
*** p<0.01, ** p<0.05, * p<0.1

The results support the a priori expectation of a positive and significant relationship between structural characteristics (access to reliable piped-water supply in residence, access to toilet facilities in residence, existence of reservoir in residence, number of garage(s) in residence) and rental values. Focusing on the main variable of interest, houses with reliable piped-water supply and/or other water-related basic attributes are associated with higher rental values. That is, holding all else constant, households with access to reliable piped-water in their residence are willing to pay 28.03% more in rental rates than those without it. By implication, access to these water-related facilities or services in residence are very relevant in Ghana and probably other developing countries with similar characteristics. Other recent African context studies had similar findings, (e.g. Choumert et al., 2014a,b; Gulyani and Talukdar, 2008; and Knight et al. 2004), as well as studies focussing on other developing countries (e.g. Vásquez (2013a, b) and Van Den Berg and Nauges (2012)). Therefore, relatively lower rental values are expected to be associated with houses without basic structural characteristics.

As earlier mentioned, neighbourhoods with better socio-economic and environmental amenities attract higher rental values. In effect, the closer a house is to quality neighbourhood characteristics that represent education, peace, safety, and wealth (i.e. brisk business activities), one would expect higher rental values. Our results is consistent with a priori expectation. It shows that neighbourhood characteristics have negative signs, with most of the variables being significant as expected. This suggests that the closer a residence is to a highway, financial institution and/or school the higher its associated rental values. Distance from financial institutions which are normally clustered in the central business district had the right negative sign yet insignificant in the preferred log-lin model.

In addition, we included a new variable, mean-district-monthly-income to represent neighbourhood socio-economic characteristics while excluding district dummies (see models 1&3 in Table 1). We found this to have a positive effect on rental values. This socioeconomic characteristic in the neighbourhood is used as a proxy to describe the level of wealth, knowledge, awareness and perception of the neighbourhood (see Van Den Berg and Nauges, 2012). Holding other factors constant, higher levels of education are normally associated with good jobs, higher earnings and property ownership. Generally, informed and wealthy household will prefer staying in a house with essential services that improves their quality of life, signifies prestige and honour in society to a house without essential services. It is important to acknowledge that, one main conclusion from this investigation is that differences in income between districts is one principal cause of differences in rents between districts in Ghana.

4.1.1 Marginal WTP for Reliable Piped-Water in Residence

To determine the marginal WTP for access to reliable piped-water in residence, we transform the regression equation 18 using anti-log. Given that the variable of interest is dummy, we first compute the relative change in rental values (p) for having access to reliable piped-water in residence as:

$$p = \exp(\hat{\beta}) - 1 \tag{24}$$

From Table 1 (Model 4), $\hat{\beta} = 0.2803$ depicting the difference in access to reliable piped-water in residence and absolute increase in rental values. Thus, relative change in rental values shows the additional amount in rent that households with access to reliable piped-water in residence are willing to pay. This study finds that the average amount households will be prepared to pay per month for access to pipe-water in residence is GHS 44.73 which constitutes 7.03% of the mean-district-income (see Table 3). This according to Bartik (1988) and Choumert et al. (2014b) should be interpreted as an upper bound values because the utility dummy may include unobserved attributes and utilities.

Table 3: Predicted Increase in the value of house with access to reliable piped-water

Marginal implicit house value per month(GHS)	Current average HH expenditure on water per month (GHS)	Increment as a % of monthly district-income	Increment as a % of Monthly Household Income
Mean[5]	Mean	Mean[6]	Mean[7]
44.73	52.22	7.03%	7.03%
[23.69-65.76]	[50.34-54.09]	[3.72%-10.34%]	[3.72%-10.33%]

95% *Confidence Interval in square brackets [ ].*

4.2 Travel Cost Results

We estimate three different models and the results are presented in Table 4. We indicate our best model and use the others for robustness checks.

Table 4: Travel Cost Regression Results

VARIABLES	(1) OLS	(2) Poisson	(3) Neg-Bin
Cost to Water Source (Log)	-4.094***	-0.040***	-0.044***
	(0.345)	(0.004)	(0.003)
Cost to Other Sources (Log)	5.930***	0.085***	0.066***
	(2.193)	(0.020)	(0.020)
Access to Rel. Piped-Water	-9.125**	-0.085*	-0.104**
	(4.600)	(0.045)	(0.046)
Reservoir in Residence	-10.140**	-0.099**	-0.110**
	(4.516)	(0.044)	(0.045)
Other Fam. Mem. HH	16.463***	0.172***	0.152***
	(5.001)	(0.053)	(0.056)
HH Income(Log)	-5.414*	-0.052*	-0.057*
	(3.051)	(0.031)	(0.030)
Savings_dum	-15.190***	-0.145***	-0.164***
	(5.219)	(0.046)	(0.050)
Constant	149.766***	4.911***	5.037***
	(21.233)	(0.208)	(0.201)
District Dummies	*Yes*	*Yes*	*Yes*
Observations	1,243	1,243	1,243
R-squared [LR-Test]	0.24		
Adjusted R-squared [Wald chi2]	0.23	[669.27***]	[535.17***]
AIC	14,298.51	69,739.43	13,664.43
Mean Variance Inflation Factor (VIF)			

Dependent Variable: Number of Round-Trip to Water Sources per Month
Robust standard errors in parentheses
*** p<0.01, ** p<0.05, * p<0.1

Before the discussion, we admit the possibility of practical estimation problems associated with TCM. Bateman (1993) acknowledges among other things inappropriate functional forms and estimation technique, truncation bias, heteroskedascity and multicollinearity as potential problems in practical TCM studies. To control for these potential problems we first test for the presence of multicollinearity using the VIF test on the OLS model. The mean VIFs is reported as 1.34 (model 1) which is even not significantly greater than 2. This implies that multicollinearity is not a severe

[5] Relative change (water dummy)×Average House Value=44.73 per month
[6] Marginal Implicit house value/Average district- income=0.07031×100≈7.03%
[7] Marginal Implicit house value/Average Household income=0.07029%≈7.03%

problem in this model. It is argued in Literature that although the "economic theory of constrained optimisation with complementarity provides no particular functional form for trip generation equations" (Wattage, 2002, p.13), [yet functional forms have] "non-trivial implications on results obtained" (Perman, 2003, p.442). We may not have a particular functional form for trip generation equations, yet, Bateman (1993) has argued that the appropriateness of a functional form can be evaluated using the relative degrees of explanation. An R-squared of 24% and an adjusted R-squared of 23% which is also seen in Creel and Loomis (1990) as generally not bad to discredit the model's appropriateness. The models are estimated with robust standard errors to control for evidence of heteroscadasticity[8]. As mentioned earlier, the OLS is estimated alongside Maximum Likelihood (ML) estimations for robustness checks. The latter is highly recommended for TCM studies to control for truncation bias (see Bateman, 1993).

The OLS is used in this study as a baseline model for robustness checks as it is not suitable for count data of this nature. The next appropriate model is the Poisson model. However, a test of over-dispersion provides evidence that the conditional variance is higher than the conditional mean. These differences suggest that over-dispersion is present and that a Negative Binomial model (Neg-Bin) would be more appropriate to use (see Table 5). This is further supported by the Akaike information criterion (AIC) tests (see Table 4).

Table 5: Test of Over-dispersion

Variable	**N*	*Mean*	*Std. Dev.*	*Variance*	*C. I. [95%].*	*Remark*
Poisson Model Test						
**No. of Trips	1243	105.487	43.858	1,923.551	103.046-107.927	[9] Evidence of Over-dispersion
Negative Binomial Model Test						
	alpha			*S.E*	*C.I. [95%]*	*Remark*
**No. of Trips	0.532933			0.022	0.500-0.568	Reject $\alpha=0$
Likelihood-ratio test of alpha $(\alpha)=0$ chibar2(01) = 6.000 Prob.>=chibar2 = 0.000						

**Where N is the number of observations. **Number of Round-Trips to Water Sources.*

From Table 5, we obtained a chi-squared value of 6.000 with one degree of freedom and a p-value of 0.000. With this, we have evidence to reject the null hypothesis that alpha is zero $(\alpha=0)$ and strongly suggest that alpha is non-zero and the Neg-Bin model is more appropriate here than the Poisson model because of its appropriateness for over-dispersed count data.

Due to the different characteristics of the districts regarding their sources of water supply, this study introduced district dummies to control for district specific effects on the number of round-trips to various water sources (see Table 4).

The variables we are most interested in are the cost related variables therefore we discuss them first followed by all other variables. As suggested by economic theory, we expect a negative relationship between the cost of the good itself (i.e. cost per round-trip to the main source of water supply per month) and the number of round-trips households make per month to other water sources. The results confirmed our theoretical priors, suggesting that for each percentage increase in the cost of round-trips to the main source of water supply, the expected count decreases by 0.044, holding all else constant. This suggests that households who spend more money in traveling to their water sources make fewer trips per month. Alternatively, we expected a positive

[8] Chi2(7)= 81.52 and Prob > chi2 = 0.0000. We rejected Constant variance.

[9] Poisson assumes that the conditional mean and the conditional variance are the same. Thus, ((Var(y|X)=E(y|X)) However, the conditional variance (1,923.551) is far greater than the conditional mean (105.487), ((Var(y|X)>E(y|X)), hence an evidence of over-dispersion.

relationship between the cost of substitutes (i.e. cost per round-trip to other sources of water supply per month) and the number of round-trips households make per month to their water sources. This also means that for each percentage increase in the cost of round-trips to the other sources of water supply, the expected count increases by 0.066, holding all else constant. This implies that in the absence of the main source, households who make more trips per month spend more money in traveling to the alternative water sources relative to the main source. These cost related variables are highly significant in all estimated models.

We find that access to reliable piped-water in residence is negative and significant. This suggests that the probability of having access to reliable piped-water supply in residence decreases the expected count to haul for water by 0.104, holding all else constant. In addition, households with access to reservoir in their residence were not expected to have behaved differently in terms of signs as it would have been an irrational behaviour on the part of the household or consumer. We again find a negative and significant effect of reservoir in residence on number of round-trips households make per month. This means that the probability of having access to a reservoir in residence also decreases the expected count to haul for water by 0.110, holding all else constant. These suggest that households with a source of water supply in their residence are expected to make fewer trips to haul for water. Having a reliable piped-water supply and/or a reservoir in residences in the form of wells and boreholes as a source of water supply do not warrant making trips to alternatives. This provides some evidence on how piped-water is very important to urban Ghana and in its absence household depend on other more expensive sources for survival.

It is evident from Table 4 that households with larger family size as a result of other family members in the household has a positive and highly significant effect on number of round-trips to the water sources. We find that the probability of having other family members in the household increases the expected count to haul for water by 0.152, holding all else constant. This implies that, by summing up all the trips by individual household members, we see this to be influencing the number of round-trips per month. It can be inferred that if all members are being tasked with household water responsibility, it means that children will definitely not be spared in this with its associated effects on their academic and personal development.

This study also finds household income variable to be negative and significant, meaning that a percentage increase in household income, decreases the expected count to haul for water by 0.057, holding all else constant. Also, saving is negative and highly significant. This implies that the probability of a household saving some of their income, decreases the expected count to haul for water by 0.145, holding all else constant. Thus, relatively wealthy households (characterised by higher earnings and positive saving behaviour) who can afford not to travel yet have access to potable water supply through tanker services which most poor cannot afford were seen to have been making less round-trips to water sources. This inverse relationship between household wealth levels and number of round-trips to water sources is as expected and it is significant in all estimated models.

4.2.1 TCM WTP Estimate (Marginal WTP)

Information on TCM survey defines the demand curve and therefore helps to determine point estimate of consumers' surplus (see Bateman, 1993; Freeman 1979). In order to estimate consumer surplus and determine the WTP for reliable piped-water supply, we now use equation 25 which is the estimated function provided by the Negative binomial (Neg-Bin model 3 shown in Table 4):

$$V_i = 5.037 - 0.044(CM_i) \tag{25}$$

According to Creel and Loomis (1990) point estimate of consumers' surplus (CS) per predicted trip $(\hat{V})$ is given as:

$$\frac{\widehat{\mathrm{CS}}}{\hat{\mathrm{V}}_{\mathrm{i}}} = -\frac{1}{\hat{\beta}_{\mathrm{i}}} = \frac{1}{0.044} = \mathrm{GHS}\ 22.72\ [19.89 - 26.62]$$

We admit that our cost to main source of water supply variable could capture not only piped-water supply but also other improved sources in some cases. This we failed to disentangle. Yet, we do not expect this to be many though as majority (over 64%[10]) in GAR depend on piped-water sources. Therefore our estimate of consumers' marginal WTP is for improved water supply and not necessarily piped-water supply. Also, it is not out of place to use improved source as a proxy for piped-water supply in this study as all piped-water supply are improved. In short, the point estimate of consumers' marginal WTP to have access to improved water supply (piped-water) is GHS 22.72 which constitutes 3.57 % of households' income (see Table 6). In spite of the fact that our model captured improved water supply, this should be interpreted as a lower bound because we used only the opportunity cost of travel time to determine the cost per round-trip made by households. By this, we do expect results from the CVM and HPM to be greater than TCM. Some studies which include but not limited to and Czajkowski et al. (2015), Hill et al. (2014) and Shrestha et al. (2002) have all used this same method in obtaining point estimates of consumers' surplus per predicted trip.

Table 6: WTP Estimate and Share of Household's income

Measure	**WTP Estimate (GHS)**	**Mean(GHS)/Month**
HH Income	22.72 [19.89-26.62]	636.37 [607.90-664.84]
% Share of HH Income in CS (WTP)[11]		3.57% [3.13%-4.18%]

*95% Confidence Interval in square brackets [ ].

[10] GSS (2012)2010 Population and Housing Census, pg.30

[11] % Share of HH Income in Consumers' surplus (WTP)=HH Income/Marginal WTP = (636.37/22.72)×100= 3.57%

4.3 Contingent Valuation Results

To determine how much households are willing to pay for reliable piped-water under this CV approach, we first investigate whether households' WTP determinants are consistent with demand theory. This section present results of three models used for the CVM. These are presented in Table 7 and subsequently discussed.

Series of multivariate regression analysis presented in Table 7 were run using test characteristics of access to water variables and some household level characteristics as controls in the models. For simplicity in our discussion, the independent variables are further put under five different categories following Lauria et al. (1999). First, respondents' personal characteristics (age, age^2 and income), respondents and other households' characteristics in residence (Number of households in residence, other family members in respondents' household, average household expenditure on water per month and household residential fence type), characteristics of administered questionnaire to respondent (Starting point amount), main variable describing respondents' household water situation (Main source for drinking and Main source for general use) and respondents' knowledge or awareness and attitudes about environmental issues (Knowledge of domestic environmental issues and knowledge of international environmental issues).

As already explained under *Obtaining Respondent's Bid* (see section 3.2.3), the dependent variable used depends on the structure of the model. For example, with model 1 (Oprobit), we ordered the final WTP amount into four different categories, Model 2 (Interval[log]) transforms the lower and upper WTP bids into natural logs and Model 3 (OLS[log]) uses the final WTP amount. Overall, the OLS model provided the best results. This is based on the fact that, in addition to its simplicity for analysis, it has the best AIC test value of 587.568. It is important to note that the adjusted R-squared of 20% for the preferred model is above the 15% proposed by Mitchel and Carson (1989) as the minimum for reliable CV studies. The mean VIF is 6.06 for our preferred model. This is quite high because of age and age squared yet it does not invalidate our results because multicollinearity is deemed not severe. Our preferred model is also estimated with robust standard errors and controls for district specific effects using district dummies. Table 7 below shows the regression results for all the six models presented, however, discussion is based on our preferred model 3.

Table 7: Regression Results-CVM

VARIABLES	(1) Oprobit	(2) Interval (Log)	(3) OLS (Log)
Main Source for Drinking Reliability Index	0.564***	0.081**	0.129**
	(0.189)	(0.039)	(0.052)
Main Source for General Use Reliability Index	0.312***	0.050**	0.068**
	(0.119)	(0.024)	(0.029)
Average HH Expenditure on Water/Month (Log)	0.090	0.021	0.034**
	(0.068)	(0.013)	(0.017)
Residence Fence Type	0.198**	0.038**	0.052***
	(0.081)	(0.016)	(0.020)
Number of Households	0.034***	0.007***	0.007**
	(0.011)	(0.002)	(0.003)
Other Family Members in HH	0.302***	0.024	0.076***
	(0.110)	(0.022)	(0.024)
Household Income(Log)	0.433***	0.084***	0.128***
	(0.053)	(0.010)	(0.014)
Age (Years)	-0.050**	-0.012***	-0.018***
	(0.022)	(0.005)	(0.006)
Age-Squared (Years)	0.001**	0.000***	0.000***
	(0.000)	(0.000)	(0.000)
Knowledge of Domestic. Environmental Issue	0.230***	0.022	0.041**
	(0.083)	(0.018)	(0.020)
Knowledge of International. Environmental Issue	0.142*	0.027	0.030
	(0.085)	(0.018)	(0.022)
Starting Point Amount (Log)	0.241**	0.389***	0.231***
	(0.113)	(0.020)	(0.028)
Constant		1.838***	2.330***
		(0.144)	(0.184)
District Dummies	*Yes*	*Yes*	*Yes*
Observations	1,014	1,014	1,014
R-squared (Adjusted R-squared)			0.22(0.21)
Log-Likelihood (LR-test statistic), [F-statistic]	167.37***	390.73***	[12.69***]
Akaike Information Criterion (AIC)	1,712.463	2,087.177	441.36

Dependent Variables: OLS (log)-MWTP; Oprobit- cat_MWTP; Interval
Interval (log)-LWTP UWTP, Robust standard errors in parentheses, *** p<0.01, ** p<0.05, * p<0.1

We commence the discussions with the main variables of interest (i.e. water related variables). There is an evidence that reliable source of drinking water supply has a positive and significant effect on WTP . This implies that households with access to reliable drinking water supply are WTP approximately 13% more than households without access, all else held constant. Furthermore, there is evidence that reliable source of water for general use has a positive and significant effect on WTP. This also suggests that households with access to a relaible source of water for general use are WTP approximately 7% more than households without access. It can be inferred that households who have reliable source of piped-water supply for drinking and general use in their residence have a higher probability to pay more for a service they are already enjoying. This shows that households with a reliable piped-water supply would be willing to pay more to keep enjoying what they have been enjoying. Moreover, households that are currently spending huge sums of money in their quest to access potable water are still indifferent with respect to their spending behaviour to access potable water. Thus, household average expenditure on water per month is positive and significant to willingness-to-pay.This provides evidence that a percentage change in a household's average expenditure on water per month will change WTP by 3.4%, all else held constant. In short, we find evidence of an endowment effect with respect to reliable piped-water supply.

Second is respondents' personal characteristics. Krupnick et al. (2002) argue that theory cannot predict exactly the relationship between age and WTP. The age variables (age and age^2) which are highly significant, together depict a U-shaped relationship with WTP. This gives a minimum turning point of approximately 40 years, which lies in a 95% confidence interval of 35-45 years. This U-shaped relationship according to Soto Montes de Oca et al. (2003) demonstrates the essential nature of the good in question with changing priorities in the lifetime of respondent. Cameron and Englin (1997) in their study on "respondent experience and CV of environmental goods", strongly recommend age as a very crucial variable in WTP studies as it provides an upper bound on respondent's experience.

Third, respondents' household characteristics. Economic demand theory suggests that, all else held constant, wealthy households will pay more for enhancement in their utility. Here, take-home income per month of household heads is used as a proxy for household income and wealth. It met the a priori positive and significant expection. This suggests that a percentage change in household income level is expected to yield approximately 13% change in their WTP for piped-water supply. Thus, water is a normal good and that households with larger income sizes are willing to pay to have reliable piped-water in their residences. Similar findings are found in Elnagheeb and Jordan (1997), Lauria et al. (1999) and Soto Montes de Oca et al. (2003). Moreover, from a general perspective, larger household sizes are expected to use more water relative to smaller household sizes and are therefore expected to pay more for quantities used. Number of households in a residence was observed to be positive and significant. This means that there is evidence that a unit increase in the number of households in a residence will increase WTP by 0.7%, all else held constant. This perhaps could be explained by the communal living effect which is a characterisic of most districts in Ghana. However, it is important to acknowledge that people are quite careful when the free riders are not from the same residence but unwanted guest. More so, we used households with other family members to capture household size. This is also positive and significant, providing evidence that, all else held constant, larger household sizes are WTP 7.6% more for reliable piped-water than those with relatively smaller household sizes. Thus, the probability of having other family members in the household increases respondents' willingness-to-pay. Similar findings are found in Soto Montes de Oca et al. (2003). Also, household fence type is positive and highly significant. This provides evidence that fenced households are 5.2% more likely to pay for reliable piped-water relative to unfenced households. The intuition underlying this result could mainly be attributed to the free riding associated with communal living societies.

Regarding respondents' awareness and knowledge of environmental issues, we used knowledge of both domestic and international environmental issues to determine households behaviour towards having access to reliable piped-water supply in residence. Thus, will households who are aware of the implications of a poor environmental community be prepared to pay more for improvement? All the models had the right signs signifying that informed households appreciate the good in question and would be willing to pay for it. However, this was significant for only domestic but not international environmental issues.

Lastly, the starting point bid[12] results show a positive and significant effect on WTP. This suggests that there is an evidence that an increase in the starting point bid by GHS1.00 will induce about 23% increase in WTP values, all else held constant. Although this study adopted the RQS as suggested in the literature to control for starting point point bias and anchoring effect, however, the models show some evidence of starting point bias. It should be noted that dichotomous choice questions are not completely free from anchoring problems (see Boyle et al., 1997; Green et al.,

[12] The starting point bids were GHS 0.2, GHS 0.3, GHS 0.4, GHS 0.5. These values were noted during the fieldwork before the first pilot survey and they represent ranges of how much a 34cm bucket of piped-water is sold within the Greater Accra Region of Ghana.

1998; Boyle, 2003). This implies that the starting point bias could have been higher without the controls.

4.3.1 CVM WTP Estimates

Table 8 presents the WTP estimates as well as its share of households WTP from the CVM method.

Table 8: Estimated Household WTP Measures

Measures	Max. WTP for a 34 cm bucket of piped-water (GHp)	95% Confidence Interval (CI)	Max. WTP reliable piped-water (GHS)/Day	*Max. WTP for reliable piped-water (GHS) /Month
Mean	39.86	38.83-40.90	1.59	47.80
Median	35.00	30.00-40.00	1.40	42.00
% share of HH monthly Income			0.25%	7.51%

*Note: Computation used a Mean Household (HH) Income of 636.372 and a CI of 607.90-664.84. *0.3986×4×30*

Available evidence from the literature in developing countries as shown by the likes of Whittington et al.(1990a,b); Whittington et al.(1991); Altaf et al.(1992); Briscoe et al. (1990); Whittington et al.(1993); Whittington et al.(1998); Soto Montes de Oca et al. (2003) indicates that the percentage of household income to WTP ranges between almost 2% to 18%. This suggests that our results fall within the range estimated in literature.

We concur that the objective of suppliers is important in determining prices. For example a profit maximizing supplier will set price to be greater than average variable cost in order to achieve his objective. Generally, setting lower prices increases demand, “other things held constant”. Alternatively, setting higher prices for a good with less or no alternatives will generate the highest expected revenue. From Table 8 it is evident that households are prepared to pay 39.86 pesewas (approx. GHS0.40) for the 34cm bucket of piped-water in their residence. From the survey, this is marginally high because it is greater than the average of what they are currently paying (GHS0.35) in the region for the same service. So by GHS1.59, the highest expected revenue per day of about GHS1,514,202.03 (US$483,030.45) is realised for the maximum reliable piped-water for a household per day. This implies that the price option for the supplier to expand coverage by providing reliable piped-water in residences and maximize revenue at the same time is approximately GHS0.40.

Also, by the CVM, we indicated that piped-water is a normal good to the people of Ghana and that households have expressed high WTP to have such a good or service in their homes to increase the quality of their lives. This constitutes 7.51% of their incomes.

4.4 Comparison of Willingness-to-Pay Estimates

The results from the competing valuation methods are presented in both Ghana cedis (GHS) and in United States dollars (US$) as shown in Table 10 below for easy comparison and comprehension.

Table 10: Comparison of Valuation Methods' Results.

Method	WTP(GHS)/M*	95% CI	WTP US$/M*	% of Income Index
CVM	47.80	[46.60-49.08]	15.25	7.51%
HPM	44.73	[23.69-65.76]	14.27	7.03%
TCM	22.72	[19.89-26.62]	7.25	3.57%

*M=Month (GHS=US$0.319 as at 15/10/2014)

Table 10 compares the three valuation methods and finds that the value from the CVM (GHS47.80 or US$15.25) is greater than the HPM (GHS44.73 or US$14.27) which is also greater than the TCM (GHS22.72 or US$7.25). These values fall within household income ranges of 3.57-7.51%. Similar findings where stated preference method estimates are greater than estimates from revealed preference methods have been found in studies by Knetsch and Davis (1966), Bishop et al. (1979), Brookshire et al. (1985), Cummings et al., (1986) as summarised in the literature of this study. In addition, as mentioned earlier Whittington et al.(1990a,b); Whittington et al.(1991); Altaf et al.(1992); Briscoe et al. (1990); Whittington et al.(1993); Whittington et al.(1998); Soto Montes de Oca et al. (2003) have also found that the percentage of household income to WTP ranges between almost 2% and 18%.

It is imperative to observe that the comparisons must however, be interpreted carefully. This is because the estimates of willingness to pay from the valuation approaches are not measuring precisely the same thing. Whilst the HPM is an upper bound which is measuring use value of current reliable piped-water service in residence, the TCM is a lower bound measuring improved water supply which includes piped-water. The CVM is upper bound measuring use value of the proposed reliable piped-water supply. Thus, TCM is interpreted as lower-bound because it used only the opportunity cost of travel time. However, HPM is upper-bound because the utility dummy may include unobserved attributes and utilities. Although the CVM is designed here to capture only use values however, we cannot rule out the possibility that some respondents may have other non-use values in mind while stating their WTP values. In sum, the CVM and HPM are upper bounds and are expected to be greater than the lower bound TCM. In addition, CVM is expected to be greater than HPM because while both include use values, HPM does not capture non-use values but CVM does.

4.5 Cost & Benefit Analysis

United Nations (2004) has indicated in their study on Freshwater Country Profile for Ghana that it costs the country US$0.80 per one m^3 (1,000 litres) to produce, transport and distribute potable water. Table 11 shows the cost benefit analysis using the equivalent cost of US$0.06 for 75litres as a proxy for the required amount of piped-water needed per household/day.

Table 11: Cost/Benefit Analysis

*Cost (HH/day)		Total Urban HH Cost/day (HH size of 950,336)		Total HH (Urban and Rural) Cost (HH size of 1,036,426)		Expected Revenue (Uban HH/day)		Net Benefit (Urban HH/day)	
GHS	US$	GHS	US$	GHS	US$	GHS	US$	GHS	US$
0.19	0.06	180,563.84	57,020.16	196,920.94	62,185.56	1,514,202.03	483,030.45	1,333,638.19	426,010.29

Note: Assuming the cost of efficient production, transportation and distribution of 75 litres is US$0.08 of piped-water to households in Ghana per day. The Household (HH) benefit of 1.59 per day is used

From Table 11, given the total number of urban households in the ten districts as 950,336. We assume the cost of efficient production, transportation and distribution of 75litres (US$0.06) of potable piped-water to households in Ghana per day is approximately GHS180,563.84 (US$57,020.16). Again, our computed expected revenue for supplies per day is approximately GHS 1,514,202.03 (US$483,030.45). Therefore, the difference between the expected revenue and the expected cost per day yields GHS1,333,638.19 (US$426,010.29) or GHS486.78million (US$155.49million) per annum. This provides evidence of a positive net benefit of the project. Similar results are found in Briscoe et al. (1990), Whittington et al. (2002), and Soto Montes de Oca (2003). We still find evidence of net benefit for both urban and rural households cost together at the same expected revenue.

The cost-benefit analysis provides evidence that, it is possible to successfully implement a full cost recovery programme in the water sector in Ghana without government subsidy. Thus, it is economically feasible to improve the supply of water in Ghana by providing reliable piped-water in residences and making the once inefficient GWCL to be managerially and technically efficient.

Also according to African Ministers Conference on Water (AMCOW, 2011), an estimated US$237million in capital investment is required annually to meet the water supply rural and urban subsector targets of the then MDGs target (now SDGs). With this, the government is expected to contribute about 50% and still leave a deficit of US$119 million per year. With the estimated revenue, it implies that even with the revenue from the GAR alone, it will take less than two years to cover the capital investment required as estimated by AMCOW. This will save the government all annual expenditures into the water sector which could be reallocated to other sectors.

In sum, this section presents how viable this project is to the private sector and the extent to which piped-water can be supplied to urban and if possible rural households while they pay the full cost of their consumption without government or donor support.

5. Conclusion

In our quest to provide empirical evidence towards implementing the full cost recovery programme in Ghana's water sector, we follow the guidelines and valuation design issues as recommended by FAO (2000) and NOAA Blue Ribbon Panel Committee (see Arrow et al., 1993). In addition, three valuation methods are employed namely the HPM, TCM and CVM to satisfy internal validity checks. A household sample of 1,648 is used from the Greater Accra Region of Ghana.

In the CV survey, the double-bound dichotomous choice formats which were followed by open-ended questions were used to elicit households' maximum WTP bids. Also, in the Hedonic survey, monthly rental values paid in the last month before the survey was used as a proxy for the market value of properties. For the TC survey, the number of round-trips to and from the water sources were used in this study. This study finds that household WTP for a reliable piped-water supply per month is GHS 44.73 or US$14.27 (HCM), GHS 22.72 or US$ 7.25 (TCM) and GHS 47.80 or US$ 15.25 (CVM) respectively. These amounts are equivalent to say 3%-8% of households' income. These results are observed to be consistent with similar studies in the literature. This study further provides evidence of the economic viability of private sector involvement in the water sector as proposed by the World Bank (1993). Overall, our results satisfy internal and external validity check criterion, and thus to a large extent we are confident of our estimates for policy decisions.

To the best of the authors' knowledge, this is the first study to use three valuation methods to a water related survey data in Africa. It complements existing studies that have combined more than one method in developing countries.

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APPENDIX

DESCRIPTIVE STATISTICS FOR HPM TCM AND CVM

Table 1: Descriptive Statistics for HPM

Type of Variable Name	Obs.	Mean (Std. Dev.)	Variable Description: Type/Codes	*A priori
Rent Per Monthly in Ghana cedis (GHS)	1648	138.23 (174.23)	Continuous 10 (Min) 1,000(Max)	n/a
Average-district monthly Take-Home Income in GHS	1648	636.18 (89.65)	Continuous 463.62 (Min) 842(Max)	+
Access to Reliable Piped-Water in Residence	1376	0.29 (0.45)	Dummy Yes=1, No=0	+
Number of Garage	1646	0.10 (0.36)	Dummy Yes=1, No=0	+
Access to Toilet in Residence	1648	0.722 (0.45)	Dummy Yes=1, No=0	+
Reservoir in Residence	1648	0.48 (0.50)	Dummy Yes=1, No=0	+/-
Distance to Nearest Highway (km)	1648	0.65 (1.64)	Continuous 0.10 (Km)- 32.14 (Km)	+/-
Distance to Nearest Financial Institution (km)	1648	0.67 (0.81)	Continuous 0.015 (Km)- 12 (Km)	+/-
Distance to Nearest School (km)	1648	0.25 (0.46)	Continuous 0.01(Km)- 9.29 (Km)	+/-

*Hypothesised on WTP

Table 2: Descriptive Statistics of TCM and CVM

Type of Variable Name	Obs.	Mean (Std. Dev.)	Variable Description: Type/Codes	*A priori
No. of Round-Trips to Water Source(s) per month	1648	99.58 (89.975)	Continuous/Count 0(Min)- 592(Max)	n/a
Monthly Take-Home Income in Ghana cedis	1604	636.37 (581.35)	Continuous 160 (Min) 4,400(Max)	+
Other Family Members in Household	1648	0.83 (0.38)	Dummy 1-Yes, 0-No(Single Adult Only)	+
Age of Respondent (Years)	1648	39.29 (11.86)	Continuous 18yrs-72yrs	+/-
Age of Respondent Squared (Years)	1648	1685.04 (986.86)	Continuous 324yrs-5184yrs	+/-
Access to Reliable Piped-Water in Residence	1376	0.29 (0.45)	Dummy Yes=1, No=0	+
Cost per Round-Trip to Main Water Source per Week (W) in Ghana Cedis	1648	9.16 (11.95)	Continuous/Count 0(Min)-1308 (Max)	-
Cost per Round-Trip(s) to Other Sources of Water per Week (W) in Ghana Cedis	1648	55.52 (27.32)	Continuous/Count 0(Min)- 1540 (Max)	-

Type of Variable Name	Obs.	Mean (Std. Dev.)	Variable Description: Type/Codes	*A priori
Maximum WTP Amount (Ghana Pesewas)	1648	39.86 (21.42)	Continuous 0 (Min)-200 (Max)	n/a
Categorical WTP	1648	1.55 (0.61)	Categorical 1 ,2, 3, 4	n/a
Lower WTP Amount	1648	31.93 (13.42)	Continuous -5 (Min)-60 (Max)	n/a
Upper WTP Amount	1648	52.93 (18.24)	Continuous 20 (Min)-210(Max)	n/a
Starting Point Amount	1648	34.95 (11.18)	Discrete 20,30,40,50	+
Number of Households	1646	4.71 (3.79)	Continuous 1 (Min)-32(Max)	+
Main Source of Household Water for Drinking Reliability Index	1110	0.03 (0.18)	Dummy Yes=1, No=0	+
Main Source of Household Water for General Use Reliability Index	1589	0.25 (0.43)	Dummy Yes=1, No=0	+
Knowledge of Local Environmental Issues	1648	0.55 (0.49)	Dummy Yes =1, No=0	+
Knowledge of International Environmental Issues	1641	0.61 (0.49)	Dummy Yes =1, No=0	+
Average Household Expenditure on water/month	1612	52.21 (38.35)	Continuous 4 (Min)- 400(Max)	+
Residence Fence Type	1648	0.59(0.49)	Dummy 1=Fenced, 0=No Fence	+

*Hypothesised on WTP