Household demand for improved water supply services in Mekelle City, Northern Ethiopia

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Abstract

With population growth and urbanization, demand for improved water services has been growing. It is imperative therefore to examine different factors that influence demand for improved water services and the resultant welfare changes. Using cross-sectional household survey data collected through structured questionnaire from ten administrative units in Mekelle City, we estimate household willingness to pay models and identify major determinant factors of demand for improved water service. In order to help us do this, we considered selection issues and estimated models using the Heckman Two-Step Estimator. Our results show that the amount of bid (amount of money households would be willing to pay) that households (already connected to private taps) would be willing to pay is positively associated with household income, ownership of the house, price of vended water and the practice of water purification. For households who are not connected to private taps, the amount they would be willing to pay for (improved) private tap connection is positively associated with formal education, housing status and gender. We also investigate the welfare gains and losses as a result of improved water service. Analytical results show that, as the number of households who subscribe to improved water service increases, there is a gain in surplus for households and revenue (producer surplus) for the municipality.

Keywords: Consumer surplus; Contingent Valuation Method (CVM); Heckman model; Mekelle; Water service; Willingness to Pay (WTP)

1. Introduction

In 2000, the UN Millennium Declaration was signed (UN, 2000). In this declaration lies the famous Millennium Development Goals (MDGs), in which countries pledged to fight global poverty and hunger, protect the environment, improve health and sanitation to the poor, and promote education and gender equality. One of the key targets of the MDGs is to 'halve, by 2015, the proportion of people without sustainable access to safe drinking water and basic sanitation', taking 1990 as the base year

(O'Hara *et al.*, 2008: 2). In this regard, access to clean water has been highlighted as an important factor to realize all the other goals and targets of the MDGs.

The grim reality in many developing countries is that potable water scarcity has become a major problem. As it stands, high population growth has been cited as one of the factors that would make it impossible for the MDGs to be met (WHO/UNICEF, 2004; Min, 2007). From a policy perspective, the fast growth of cities and populations in the developing world has made it difficult for policy makers and authorities to keep pace with the ever-increasing demand (Biswas, 2006; Varis, 2006). It can therefore be argued that Say's classic economic concept of supply creating its own demand has not been vindicated so far as water is concerned (Kates, 1998). The situation in the growing urban cities of developing countries is that demand for drinking water continues to increase but supply lags behind. The situation is clearly complex; but what exactly does demand for improved water supply constitute? O'Hara *et al.* (2008: 2) state that demand for an improved water source constitutes 'connection or access to a public standpipe, borehole, protected well, protected spring or rainwater collection facility, capable of providing 20 liters per capita per day, at a distance of no more than 1,000 m [meters]'.

The literature is particularly rich with regard to the demand and pricing of water, either considered as a public or private good (see, most notably, Nordin, 1976; Williams, 1985; Dandy *et al.*, 1997; Arbués *et al.*, 2000; Massarutto, 2007; Min, 2007; Ruijs *et al.*, 2008). In the face of population growth and urbanization in developing countries (and hence, growing demand for water) however, studies that attempt to explore the willingness to pay for improved water services are limited. A study by Whittington *et al.* (1990) attempted to test the validity of the Contingent Valuation Method (CVM) for water services in rural areas of developing countries but focuses largely on the validity of the method itself. Venkatachalam (2006) examined the determinants of willingness to pay for improved water services in peri-urban areas. However, the study does not explicitly show the treatment of true zeros and protest zeros in estimating semi-log regression models; it rather seems that the true zeros are mixed with the protest zeros and treated as missing observations in the regression models. Under such conditions, omission (discarding) true zeros may lead to sample selection bias which could have two consequences: first, the empirical analysis of the valuation function used to test for theoretical validity may give inconsistent parameter estimates similar to those stated in Heckman (1979) or Amemiya (1984, 1985); secondly, the estimated benefit measures and hence the aggregated values may also be biased. Said (2003) also used CVM to estimate the value of improvements in water supply reliability in Zanzibar town. In his study, 36% of the respondents were not willing to pay any amount due to true zero reasons. Said employed ordinary least square (OLS) regression with these bulk true zero responses. But, including true zero observations results in biased as well as inconsistent OLS parameter estimates (Gujarati, 2003). Casey *et al.* (2006) estimated willingness to pay models using OLS regression but did not attempt to examine the welfare gains. With this study, therefore, we take into account these limitations in analyzing the willingness to pay for improved water supply service in the context of developing countries. In this regard, the specific objectives are: (1) to estimate and find out the factors that determine the amount of bid given households are willing to pay improved water service; (2) to explore the factors that influence willingness to pay for improved water service; and (3) to estimate the welfare gains and losses in relation to the expansion of improved water service. For analytical purposes, we use the Heckman Two-Step Estimator by considering and incorporating true zero responses. As we have observed, we have the problem of censoring in the open-ended questions and the appropriate model is censored regression, where there is censoring from below at zero willingness to pay. Thus, censored regression under the Heckman correction has become the appropriate method in this study to solve

the aforementioned pitfalls in empirical analyses. A CVM study should be concluded by analyzing the welfare gains and losses of the proposed improved water supply service. Unlike most other studies, therefore, we go one step further to illustrate how welfare of households and society changes as a result of the improved water service. We focus on demand for improved water service in an urban setting, with a case study in one of the fastest growing urban centers in Ethiopia: Mekelle.

The rest of the paper is presented as follows. Section 2 provides the theoretical and econometric modeling for willingness to pay for improved water service. Section 3 briefly describes the study area, and water demand and supply situation of the city of Mekelle, giving the reader a general impression of the city. Analyses and discussion of the results are presented in Section 4. Finally, Section 5 presents summary conclusions and implications for policy.

2. Conceptual modeling and econometric specification

The most notable instances where the price system fails to give market values involve environmental (natural) resources. But, when policy interventions are envisaged (such as willingness to pay studies), the usual market system may be difficult to implement. In such cases, economists try to apply 'implicit market' mechanisms which enable us to estimate economic value of these non-market goods (such as improved water supply services). CVM[1] is one of these 'implicit market' mechanisms. The use of CVM enables a researcher to elicit the stated preference of an economic agent (households in this study) for obtaining more or better services or goods. The willingness to pay questions in CVM ask households to speculate on how much they would be willing to pay for a certain good or service (example, for improved water supply services). Typical components of a contingent valuation method include the description of the improved water service on offer and the mechanism to elicit household willingness to pay for the service.

In this study, improved water service applies for three different hypothetical scenarios where the proposed water service[2] is better than the status quo. One scenario refers to households who already have a private tap connection and are interested in having an improved water service. This improvement incorporates improved quantity (good pressure), quality (such as non-salty water) and reliability (everyday availability of water for 24 hours) under the new scenario. The second scenario refers to households who do not have a private tap connection and are interested in having a private tap connection along with improved quantity, quality and reliability. The third scenario refers to those households who do not have a private tap connection but would be interested to have a nearby public tap connection along with improved quantity, quality and reliability.

The basic assumption in this case is that households make their decision on whether to purchase the improved water supply service on utility optimization. One important factor that determines household utility maximization is the attributes related to the service from which the utility is derived. Therefore, the decision of a household, of whether to buy improved water supply services, is made based on the utility that the household derives from the particular service that it chooses to use (Devkota *et al.*, 2004). The utility derived by a household from the choice of an alternative water supply service is specified to be the sum of a deterministic and random component (Devkota *et al.*, 2004). In such cases,

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[1] See Whittington (1998) for an extensive discussion of the contingent valuation method.
[2] Please note that 'improved water supply service' and 'improved water service' have been used interchangeably throughout this paper.

the deterministic part of the indirect utility for improved water supply services depends on observed attributes of the alternative services chosen, various household features, water and institutional attributes. To motivate our analysis, suppose U_i is the unobserved utility derived from improved water service and U_c is the current threshold level of utility. In this stance, a rational household (as a unit) is assumed to purchase ($WTP_i = 1$) (where WTP represents Willingness to Pay) the improved water service at a specific bid if the following holds true:

$$WTP_i = \begin{cases} 1 & \text{if } U_i \geq U_c \\ 0 & \text{if } U_i < U_c \end{cases} \tag{1}$$

Given that the household has the objective of maximizing utility, the decision to purchase the improve water supply service is based on the difference in utility:

$$U_i(I, x, H; \varepsilon) - U_c = 0 \tag{2}$$

Notice that the unobserved utility derived from improved water service is explained by income (I), attributes of the improved water service (x), household features (H) and an unobserved random component (ε). It follows that the household would purchase the improved water service if the derived utility from the service is larger than the current threshold level of utility from the service. Otherwise, a rational household would not be willing to pay for the service.

As a point of departure within this framework, we should consider the empirical analysis of the amount that households are capable of paying for the improved water service, given that they are willing to purchase it. Such analyses requires care because, if we consider all observation units (those willing and unwilling to pay for the improved water service) in estimating WTP, we run into the problem of sample selection. The Heckman selection model considers this problem and the relationship can be illustrated as follows: suppose the willingness to pay for improved water service is:

$$Z_i^* = \gamma' w_i + u_i \Rightarrow Z_i = \begin{cases} 1 & \text{if } Z_i^* > 0 \\ 0 & \text{otherwise} \end{cases} \tag{3}$$

$$\text{Prob}(Z_i = 1) = \Phi(\gamma' w_i) \quad \text{and} \quad \text{Prob}(Z_i = 0) = 1 - \Phi(\gamma' w_i) \tag{4}$$

Z_i in this case represents households' decisions for having (willingness to pay) improved water services. In Equation (4), willingness to buy an improved water supply service is relevant to households who have a private tap connection but want improvements of water supply service in terms of quality, quantity and reliability. Given this condition, the estimation of bid amount that households are able to pay to secure the improved water service is stipulated as:

$$Y_i^* = \theta' x_i + \varepsilon_i \Rightarrow Y_i = \begin{cases} 1 & \text{if } Z_i = 1 \\ 0 & \text{otherwise} \end{cases} \quad (i = 1, 2, \ldots, n) \tag{5}$$

The equation of interest (bid amount that households are able to pay) as shown in Equation (5) is observed only when $Z_i = 1$, i.e. provided that households are willing to purchase the improved water service. Mathematically, given the equation of interest (Equation (5)), this is given by:

$$Y_i = Y_i^* \text{ if } Z_i = 1$$
$$Y_i \text{ is not observed if } Z_i = 0 \quad (i = 1, 2, \ldots, n)$$

$$(6)$$

where Y represents maximum willingness to pay (WTP) which is censored at 0; x is a matrix of explanatory variables that influence amount of bid to pay for the improved water service; Z is a vector of dummy variables which is equal to 1 when the household decides to purchase improved water supply service, and 0 otherwise; w is a matrix of explanatory variables which influence the willingness to have improved water supply services, γ and θ are vectors of unknown parameter to be estimated corresponding, respectively, to the matrices of explanatory variables w and x. The two error terms u and ε are assumed to follow bivariate normal distribution given by $(u_i, \varepsilon_i) \approx (0, 0, 1, \sigma_\varepsilon; \rho)$, which are correlated with correlation coefficient of ρ. Z^* and Y^* are latent (unobserved) variables corresponding to Z and Y.

It follows that the equation that we estimate finally is:

$$E(Y_i | Z_i = 1) = \theta' x_i + \rho \sigma_\varepsilon \lambda(\gamma' w) \tag{7}$$

With Equation (7), we estimate the bid amount that households are willing to pay, given their consent to purchase the improved water service. This model is then estimated by the Heckman Two-Step Estimation procedure shown as follows:

1. estimate a probit model for Equation (3) by maximum likelihood to obtain estimates of γ. Then, for each observation in the selected sample, compute:

$$\lambda = \frac{\phi(\gamma' w)}{\Phi(\gamma' w)} \tag{8}$$

   Equation (8) is the Inverse Mills Ratio (IMR). The terms ϕ and Φ are the normal and the cumulative distribution functions, respectively;

2. estimate θ and $\theta_\lambda = \rho \sigma_\varepsilon$ by least squares regression of Y on x and λ. By introducing λ, which is the IMR, in the amount of bid households are able to pay for improved water service looks like the model given in Equation (7). The IMR is used as an additional regressor in the maximum willingness to pay model (Equation (7)) with a view to controlling for selectivity bias (λ). The bias due to non-random sample selection of each scenario will be measured by the coefficient of λ. If the coefficient is statistically significant, the null hypothesis of 'no bias' will be rejected.

From Equations (3) and (5), if u_i and ε_i are uncorrelated, then Equation (7) can be estimated using ordinary least square. However, if u_i and ε_i are significantly correlated, then there is the problem of sample selection bias, and estimation of the maximum WTP in Equation (5) using the least square method of regression is an inconsistent estimator of θ. This is because the second term on the right-hand side ($\rho \sigma_\varepsilon \lambda(\gamma' w)$) of Equation (7) is non-zero. Under the joint normality assumption of (u_i, ε_i), therefore,

a selection model is used to estimate the maximum willingness to pay model of Equation (7) (Heckman, 1979; Wooldridge, 2002).

3. Study area and data

3.1. Description of the study area

The city of Mekelle is located in the northern edge of Ethiopia is situated 783 km from the national capital, Addis Ababa. Geographically, it lies between latitude 13°32′ North and longitude 39°28′ East, and is accessible by highway and air transport. In 1984 the area of the city was estimated to be 16 km², growing to 23.04 km² in 1994. Showing a dramatic expansion, the city had reached more than 100 km² in 2004 by engulfing a large extent of agricultural lands, villages and towns (Tadesse, 2006). Currently, Mekelle City is one of the fastest growing cities in Ethiopia with a total area of 150 km² (Mekelle Water Supply Service Office, 2008). The population of the city has also grown, from 98,825 in 1994 to 237,320 in 2007 (Defere, 2007). The city has shown rapid growth and development in all social, economic, political and cultural spheres. Remarkable investment and works in hotels, housing, education, roads, tourist resorts, and other marketing infrastructures and services have been undertaken.

3.2. Water demand and supply in Mekelle

According to the ministry of water resources (2003), Ethiopia has one of the lowest water supply coverage levels in the world, even low by the standard of Sub-Saharan African countries. Amongst other things, inappropriate technology choice, a supply-driven approach to project design, and failure to involve user communities in decision-making processes at the project preparation stage have contributed to retarded growth in water supply coverage. At the moment, Mekelle City is facing unreliable and inadequate supply of water and sanitation services. Some of the major reasons include the high population growth, urban expansion, increased rural–urban migration, system leakage, financial constraints, and inadequate administrative and technical skills.

The current water supply comes from 15 boreholes having inadequate yield to satisfy the growing demand in the city. The existing supply was augmented by additional wells constructed by the water authority, but still the city suffers a water supply deficit. Rampant economic activities, expansion of urbanization and the growing population have contributed to the pressure on the water supply. As a result, the water supply system cannot meet the demand of the city because the sources are insufficient. In addition, the water-network distribution covers less than 60% of the city and customers are not satisfied with the service provided by the utility (Defere, 2007). At the end of 2008, water supply coverage in the city reached 55% (Mekelle Water Supply Service Office, 2008). The present water supply capacity is about 9,000 m³/day, whilst the demand is 22,000 m³/day. The operational tariff for water supply service has long been unchanged and remained a fixed tariff rate. Until the recent past, the tariff for public tap water was Birr[3] 1.75/m³ and, for all other connections, Birr 1.50/m³. However, the Mekelle Water Supply Service Office (MWSSO) (2008) indicates that the utility is spending more than

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[3] The Birr is the Ethiopian currency and, at the time of data collection in mid 2008, $US1 = 10.75 Birr.

Birr 4 to produce $1 \, \text{m}^3$ of water. Considering the various drawbacks of the existing tariff, the Water Service Management and the Board decided to revise the existing tariff across the structure and the rates. Hence, a new tariff structure was introduced in July 2007. According to Defere (2007) the existing minimum tariff rate for the residents of the lower block[4] is Birr $2.30/\text{m}^3$/month (which is 5 cents per bucket). Next to this, the minimum tariff rate has been provided for public tap users, at Birr $2.90/\text{m}^3$ for any amount (flat tariff rate), whereas the highest tariff rate is Birr $6.10/\text{m}^3$/month (12 cents per bucket) for residents of fourth block consumers, and any amount for government and commercial users. Domestic water demand includes water for drinking, food preparation, washing and cleaning, and miscellaneous domestic purpose. The non-domestic (institutional) demand, which includes commercial, industrial, public utilities and services consumes around 50% of the water demand (Mekelle Water Supply Service Office, 2008). In this regard, according to the MWSS Office Annual Report (2007) the total number of tap connections (private, commercial, government and institutional) was 20,913, out of which 18,653 were private tap connections.

These grim statistics call for immediate efforts to improve the existing water supply service and promote the construction of new supplies, so as to cope up with the increasing demand for water. To find a solution to the existing water supply service problem, the water utility should be enable to link itself with its customers and stakeholders for the communal advantage of all residents of the city. Besides supply-oriented approaches, however, an assessment of the effective demands of the majority of the households needs to be made. According to Whittington *et al.* (1990) a new vision based on the demand-oriented approach has emerged. This new approach asserts that water utility bodies need to understand actual household water use behavior and the observed ability and willingness to pay for improved water services, which motivates this study.

3.3. Data

In order to collect the data for the study, we used a two-step sampling strategy. We established clusters based on the 10 *tabias*[5] of the city. Then, we randomly selected a proportional number of households from each *tabia*, stratified by customary household economic status (such as housing and wealth). To select the sample households, we also considered various criteria such as population size and current water supply services. Based on this, we selected a total number of 225 households. So as to administer the collection of data, four enumerators and one coordinator were hired and trained for the main survey. A structured questionnaire was prepared. As preparation for the main survey, a pilot study was conducted for two days. Three respondents from each of the 8 *tabias* and a total of 24 respondents were interviewed. In this phase, four enumerators, one supervisor and the researchers participated. A number of appropriate modifications were made to the composition of the questionnaire as a result of the pilot survey. The pilot survey was also useful when setting the initial bid for the elicitation method (it helped to give some idea about setting the starting bid value). During the pilot survey, the willingness to pay part was open ended. From the different answers recorded, we took the three more frequent values (15, 20 and 25 cents per bucket of water) as initial bids of willingness to pay.

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[4] The 'lower block' represents the lower water band with less than 5 cubic meter of water consumption per month. And, the 'fourth block' represents consumption of more than 20 cubic meters of water per month.
[5] A *tabia* (plural *tabias*) is the smallest administrative unit in the study area.

The final survey was conducted from 6–20 May 2008 and was successfully completed with a relatively small number of invalid responses (about 2% protest zeros). The household survey included questions about socio-economic characteristics, water-use and sanitation practices, willingness to pay for improved water service, housing characteristics and household assets, occupation and monthly income and expenditure. The questionnaire was designed in a way that relevant variables (see Table 1) could be collected for the estimation of household willingness to pay for improved piped water supply. The single bounded elicitation format with an open-ended follow-up questions was applied for the elicitation part, as it minimizes the strategic bias and makes the decision most efficient. Apart from the information obtained from households, discussion of water supply and sanitation was also held with some stakeholders, namely with the Mekelle Water Supply Service Office (MWSSO) manager, Mekelle Bureau of Health (Sanitation Department), local consultants and other stakeholders.

3.3.1. Qualitative data description: current water use patterns and problems. Almost all of the households surveyed (99.1%) used piped water as the main source of water for domestic purposes. Less than 1% of households used dug wells as a source of potable water. Sources of piped water in the study area are house connected, private tap in compound, pipe shared in compound, private venders and public taps. Out of the total sample households, 83.2% of them use water services inside the compound (tap in house, private tap and shared tap in compound). The remaining 16.8% of the households use water from other sources (private venders, public taps and dug wells). The data indicate that 15% of the total households obtain piped water purchased from private vendors who have connection to the existing piped water system. Those who have private connection to the system (in their houses or in compounds) account for about 30.9%, while 52.3% have a shared pipe in their compound. The average number of

Table 1. Descriptive statistics of main variables, showing mean values and standard deviation (S.D.).

Variables	Mean	S.D.
Monthly income of the household (in Birr)	1,539.19	1,261.83
Family size of the household	4.81	2.24
Formal education (1 if yes, 0 otherwise)	0.68	0.46
Informal education (1 if yes, 0 otherwise)	0.1	0.72
Sex of respondent (1 if female, 0 otherwise)	0.84	0.36
Age of respondent (age in years)	38.55	16.11
Price per bucket of vended water (in cents)	31.63	21.17
Household water purification practice (1 if they use water purification; 0 otherwise)	0.05	0.23
Housing status (1 if house is owned by household, 0 otherwise)	0.66	0.47
Respondent marital status (1 if married, 0 otherwise)	0.45	0.49
Initial bid per bucket (= 20 liters) (in cents)	19.84	4.20
Monthly expenditure for water consumption (in Birr)	23.45	21.06
Daily water consumption of the household in number of buckets	2.83	1.79
Perception of satisfaction of the household with the existing toilet services (1 if dissatisfied; 0 otherwise)	0.33	0.47
Perception of quality about the existing water source (1 if poor quality, 0 otherwise)	0.14	0.35
Availability of water tank for storage (1 if yes, 0 otherwise)	0.09	0.29
Time taken to fetch water per trip (in minutes)	14.98	19.42

households who use a shared tap in a compound is 3.87, with a minimum of 2 and maximum of 13 households. About 0.9% of respondents get water from public taps (see Table 2).

Households use the existing water supply for drinking, cooking, washing, bathing and other domestic uses. Moreover, they also use it for gardening and livestock drinking. Households' average daily water consumption is about 56.6 liters. The average daily per capita water consumption is found to be 11.8 liters, which is low even compared to the minimum national target of 20 liters per day. The price per bucket of water ranges from 5 cents (official tariff), for those connected, to 100 cents for households who buy from private vendors. Given such tariffs, those households who are privately connected can still be observed buying water from private vendors due to the unreliability of the existing supply service. These households, when using private vendor for water, pay 38 cents per bucket on average. They also spend an average of 18 minutes to collect water in a trip, within a range of minimum 5 minutes and a maximum of 1.5 hours. The majority of households were informed about tariff increments and the majority of them (81.6%) maintain their volume of water consumption in the face of tariff increments.

Around 23% of the households who are connected to a private pipe in a compound believe that they enjoy a good quality of water. On the other hand, among households who fetch water from outside their compound for domestic use, only 8.6% believe that the current potable water quality is good. Of the households connected to a private pipe in a compound, only 10% felt that they enjoy enough quantity supply (pressure) of water, whilst, for households who fetch water from outside the compound, 8.8% believe that the quantity of water supplied is enough.

It is common to see water becoming available at night instead of during the day. This may cause wastage of water due to overflow of water from containers at night. It is therefore important that Mekelle Water Supply Service Office provide its service during the day, with a known quota and schedule for each *tabia*. On average, households receive water service 4 days per week (average of 9.4 hours each day). It is also common in some *tabias* (such as Adi Hawsi) for water to become unavailable for about a week during the winter season. The main reason stated for such interruption of water supply service is shortage of water from the sources. During interruptions, households use their own reserves, other pipes where water is available, springs and wells.

It was observed that households are highly unsatisfied with the existing water service. About 87.7% of the households have the strong perception that current water supply services are of poor quality, quantity and reliability. In addition to this, higher costs of water and higher connection charges are mentioned by different households as the most serious problem with the current water service in the city. On the contrary, 12.3% of the respondents are adamant that they are satisfied with the existing water supply service. Preliminary cross-tabulation of the data confirmed that households who are dissatisfied are seeking more improved water supply services and are more willing to pay for such services.

Table 2. Households' major connections to water sources.

Access to water	Share of households (%)
Piped in the house	0.9
Pipe in compound (private)	30
Pipe in compound (shared)	52.3
Private vendors	15
Public taps	0.9
Dug wells	0.9
Total	100

One important variable concerns households' attitudes towards the responsibility for improved water provision. A large proportion of the respondents (94.1%) believe that the government (local municipality) should provide subsidized improved water services to citizens, while 5.9% of the households think that either the community or private sector should be responsible. Another important perception variable is the intensity of current water problems and the efforts needed to be made by government in solving them. Out of the total respondents, 94.5% perceive that the current situation (about the provision and standard of the water supply service) is an issue of critical importance and a serious problem. Only 5.5% of the households believe that the current water supply service is not an issue of serious concern. All these perception lead to the idea that government and other stakeholders need to pay much attention in solving domestic water problems.

4. Results and discussion

The way the contingent valuation method was conducted was described in Section 3.3. For valuing an improved water supply service (which includes improvement in quantity, quality and reliability of water, having private tap or public tap connection), we used three initial bids chosen based on the frequency of responses during the pilot survey. These initial bids were 15, 20 and 25 cents per bucket of water, which is proportionally distributed to the respondents. Based on this, some relevant results have been obtained.

Calculations indicate that the mean willingness to pay (WTP)[6] for improved water service is 16.2 cents per bucket of water for the total sampled households. This indicates that households in Mekelle City are willing to pay more than the existing tariff rate, which is around 5 cents per bucket of water for the lowest consumption bundle (Birr 2.30/m³) and 12 cents per bucket for the highest consumption bundle (Birr 6.10/m³). The figures differ slightly when we consider connection to private taps. Of the total sample, 66.8% of the households already have private tap connection and, on average, they are willing to pay 16 cents per bucket of water for improved supply service (quality, quantity and reliability). On the other hand, 29.1% of the households do not have a private tap connection and they are willing to pay 16 cents per bucket to have a private tap connection together with improvements in quality, quantity and reliability. The remaining 4.1% of the households do not have a private tap connection and are willing to pay 17 cents per bucket to connect to improved public taps along with improved water service.

4.1. Econometric results

Let us now focus on the different factors that influence the (amount of) WTP for improved water services. Based on the theoretical and analytical underpinnings provided in Section 2, the Heckman selection model has been used to estimate the models, and results are presented in Tables 3 and 4.

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[6] The mean willingness to pay (MWTP) is obtained by dividing the total WTP per bucket of water for each scenario by the number of households (in that scenario). Generally, the MWTP is the arithmetic mean of the respondents' WTP under the new scenarios. Based on this, the overall MWTP for the whole sample of 220 households was found to be 16.2 cents/bucket of improved water service. In relation to this, households who have a private tap connection but are interested in improved water service are willing to pay, on average, 16 cents/bucket. Similarly, households who do not have a private tap connection but are interested in private tap connection along with improved water service are willing to pay, on average, 16 cents/bucket. The survey result indicates that the mean willingness to pay for these two scenarios is the same.

Table 3. Estimates of factors that influence WTP for households connected to a private tap.

Variables	Outcome equation		Selection equation	
Dependent variable	WTP bids		Willingness to buy improved water services	
	Coefficient	S.E.	Coefficient	S.E.
Sex of the respondent	0.94	1.95		
Water purification practice	6.93	2.4*		
Price of vended water	0.11	0.03*	0.008	0.005
Initial bid			0.03	0.02
Time to fetch water (minutes)			0.003	0.004
Monthly income of the household	0.002	0.0005*	0.0004	0.0001*
Housing status	9.64	1.54*	1.60	0.21*
Marital status	−3.04	1.36†		
Availability of storage tank	0.64	2.37		
Mills ratio (λ)	6.17	1.87*		

Significance level: *1% and †5%.

In the regression results, the test for sample selection bias in the willingness to pay models indicates that the null hypothesis of no selection bias ($H_0: \lambda = 0$) is rejected at 1% level of significance (see Table 3). Thus, the sample selection problem has to be accounted for. In this case, the selection correction term (λ) is an indication of sample selectivity bias and the Heckman sample selection model should be used to get consistent estimates. In the presence of selection bias, OLS estimates would be inconsistent. In our analysis, we consider two different scenarios. One is the regression where WTP (in cents per bucket) for improved water supply services is estimated for households who already have private taps but need improved services. The result of this model for the major variables is presented in Table 3. Prominent demographic variables such as age, education level and family size are found to have no statistically significant influence on the amount of payment for improved water services. The results, however, are interesting. One major result is that income has a positive and statistically significant impact on the

Table 4. Estimates of WTP for connection to private taps.

Variables	Outcome equation		Selection equation	
Dependent variable	WTP bids		Willingness to have (connect to) private tap	
	Coefficient	S.E.	Coefficient	S.E.
Formal education	4.07	1.93†		
Informal education	4.31	5.25		
Sex of respondent	6.26	2.11*		
Price of purchased water	0.05	0.04		
Housing status	4.57	2.08†		
Water consumption per day			0.07	0.05
Toilet status			0.66	0.19*
Age of respondent			−0.01	0.006‡
Monthly water expenditure			−0.02	0.006†

Significance level: *1%, †5% and ‡10%.

amount of bid to be paid. This result is consistent with economic theory that postulates that income is positively (directly) related to demand for a good or service. In this particular case, an improved tap water (with better quality and quantity) can be considered as a normal good, in which case the demand for better quality (and quantity) of water increases with household income. Similarly, income has also a significant impact on WTP. The implication is that, with income, the likelihood that households would be willing to pay for the improved water service increases.

Another result consistent with theory is reflected by the price households have to pay when they want to buy water from vendors. This could be conceived as water that must be bought from the 'market'. It is particularly common in cities like Mekelle to see households buying water from next door, where there are usually price takers (buy water at the price sellers set). Prices for such vended water usually increase over time. As a result, households react to such price rises. In this regard, results show that price (in cents) per bucket of water that must be paid when buying water from an outside source (vendors) significantly influences bid payments for improved water services. The positive coefficient for price of vended water indicates that households are willing to pay more for improved water services as the price of vended water increases. When buying water from vendors, households pay a higher price than what they could be charged by the municipality (which is subsidized). During frequent water interruptions, therefore, these higher prices and additional labor time costs motivate households to pay more for improved water services. Price per bucket of vended water also significantly influences willingness to pay for improved water service. The positive coefficient for price of vended water indicates that household probability to buy improved water service increases with increase in the price of vendor water.

Another factor that has a significant influence on amount of bid is the practice of water purification before use. The practice of water purification (say, before drinking) has a significant positive impact on bids to be paid for improved water services. Households that use purification methods (such as boiling) are willing to pay more for improved water service as compared to those that do not practice it. An explanation could be that households that use water purification are more sensitive to water quality and hence health issues. This may encourage them to pay more for better water services. The type of dwelling also presents an interesting result. As expected, this variable is found to be positive and statistically significant. Households living in their own houses are willing to pay more for the proposed improvements. As an asset (or wealth), the value of the house can be augmented by ensuring the presence of potable water of reliable quality and quantity. It could be related to the notion of 'property right' where households augment the 'quality' of their dwelling house through improved water services for which they would be motivated to pay more. Housing status also significantly influences the likelihood of purchasing improved water services. Results indicate that households living in their own dwelling have a higher probability of WTP for the improved water service. Marital status, about which theory does not have any prediction, is found to have an unexpected negative influence on amount of bid. Although the hypothesis was that marital status is positively associated with demand for improved water services, the result contradicts this expectation, for which we do not have a definitive explanation. On the other hand, an interesting methodological result is depicted by the coefficient of initial bid. This variable has a positive sign but is insignificant, showing that there is no significant starting bid bias. Before conducting the main household survey, we took the liberty of undertaking a pretest in order to avoid (minimize) any shortcomings, including the identification of possible starting bids. The fact that initial bid is found to have a positive but statistically insignificant coefficient could be an indication for the absence of initial bid bias.

In the second scenario, we consider analysis of households' WTP in order to be connected to private taps. Results from this model are presented in Table 4. In this model, the use of the Heckman selection model is supported since the regression results show that the null hypothesis of no selection bias (H_0:$\lambda = 0$) is rejected at 1% level of significance.

Respondents' formal education is positively associated with higher bid amount in order to be connected to a private tap; by contrast, results indicate that, among illiterate and informally 'educated' respondents, there is no significant difference in the amount of bids they would be willing to pay. This may be due to the awareness that education is expected to create about the benefits of having a private tap connection. Gender issues and activities also influence the willingness to pay more for private tap connection. This is particularly the case where women in many (cities of) developing countries carry the burden of fetching water and doing domestic activities that use water as an input. These women clearly feel the burden of not having a private tap in their house or compound. The results indicate that women are willing to pay more for the improved water supply service of having a private tap.

The price of water that households not connected to private taps pay appears to have no statistically significant influence on WTP bids. Those households who are not connected to private taps usually use public taps, where prices are distinctively lower than private vendors. Such households as a result may not be sensitive to water prices since they usually buy from public taps (whose subsidized price helps minimize water costs). Housing status is an influential factor in the demand for installation of a private tap. Households who own the house in which they live are willing to pay more to be connected to private taps. Logically, it may not be possible for households to have private taps installed if they do not own their houses. Level of satisfaction of the household with the existing toilet services has a positive sign and it is significant. Households who are dissatisfied with current toilet conditions are more likely to pay to have private tap connection. Clear-cut explanations cannot be given for such relationships; yet it could be because households who are dissatisfied with the existing toilet service need improvement in sanitation and hence are more likely to pay for having private tap connections, which ensures adequate access to water (and better sanitation). Age of the respondent has a negative sign and is significant, indicating that with increase in age the probability of having private tap connection falls. The negative sign showing that older people, who used to live with a freer water supply, may be reluctant to prefer private tap connection since they expect a cost of connection for the improved scenario. The amount of money spent on water per month is also found to have a statistically significant impact on WTP. The results show that monthly household expenditure on water consumption is inversely associated with WTP. Households that have a history of a high monthly expenditure on water are less likely to pay for private connection. The reason could be that households with high monthly expenditure on water have less probability for private tap connection since they expect higher bill charges for the improved scenario than households with existing low monthly expenditure on water.

4.2. Welfare gains and aggregation

In the previous section, we analyzed the factors that influence WTP for improvement in water supply service. Theoretically, after identification of influential factors comes aggregation, which is the last part of the contingent valuation (CV) survey. In this section, total household willingness to pay and total revenue at various prices (bids) for a bucket of water (a 20 liter container) in the study area are presented. It shows the possible benefits that could accrue if improvements are undertaken. We use mean WTP as our welfare measure, implying the use of Hicks–Kaldor compensation criterion or

Pareto improvement (Posner, 2007). At another point, we also attempt to show the welfare gains and losses using consumer surplus in relation to the expansion of improved private tap connections to as many households as possible.

Since the sample households are drawn from the main part of Mekelle City, aggregation is made to the sum of households of the main part, which is 38,777. Summation of the total WTP values in column 4 (Table 5) gives the grand total WTP amount. Calculations show that the total amount all households in Mekelle are expected to pay if the proposed improvement in water supply service is implemented equals Birr 6,281.87 per bucket of water. The survey result indicates that average household daily water consumption is 2.83 bucket of water. This gives a total WTP of Birr 17,777.7 per day, or Birr 533,330.8 per month for the proposed change (for the residents of Mekelle City).

The sum totals that households would be willing to pay include additional revenue for the municipality. This amount of added revenue indicates the existence of a strong potential to succeed if an improved water supply service is realized, based on fair user charges. Mean willingness to pay figures, recorded in Table 5, show the variation in bids to pay for the improved water service among the various *tabias*. Some of the highest bids, in Adi-Hawsi, Hawelti and Kedamay Weyani, provide important information. These three *tabias* are the main geographical clusters of the city where many medium- and high-income households live. Currently, the municipality charges households different price bands based on their ability to pay (from lower to higher price bands—see Section 3.2). Therefore, based on the bids for improved water service, there arises an opportunity for the municipality to levy higher charges on such households and improve the welfare of poorer households.

The fact that the water supply is a publicly provided service has implications for the consideration of efficiency and equity issues in setting service tariffs. This is because with quality improvement and expansion of water supply service, there is a gain in social welfare as we illustrate below (see Figure 2). Hence, the municipality has to find ways of improving the service by taking advantage of the strong household willingness to pay. In order to corroborate this argument, we used the survey data to sketch demand curves for the proposed improved water service (see Figures 1 and 2). We did this in terms of the total number of households who would be prepared to pay at least the midpoint bid for an improved service (see Table 6). Using these data, we illustrate in Figures 1 and 2 how society's welfare (using the concept of consumer surplus) can be improved if the proposed water supply service is implemented. The possible benefits as a result of the improvements in water supply service are depicted in terms of surplus gains for households and increased revenue for the municipality.

Table 5. Variations in willingness to pay (WTP) for each *tabia* in Mekelle City.

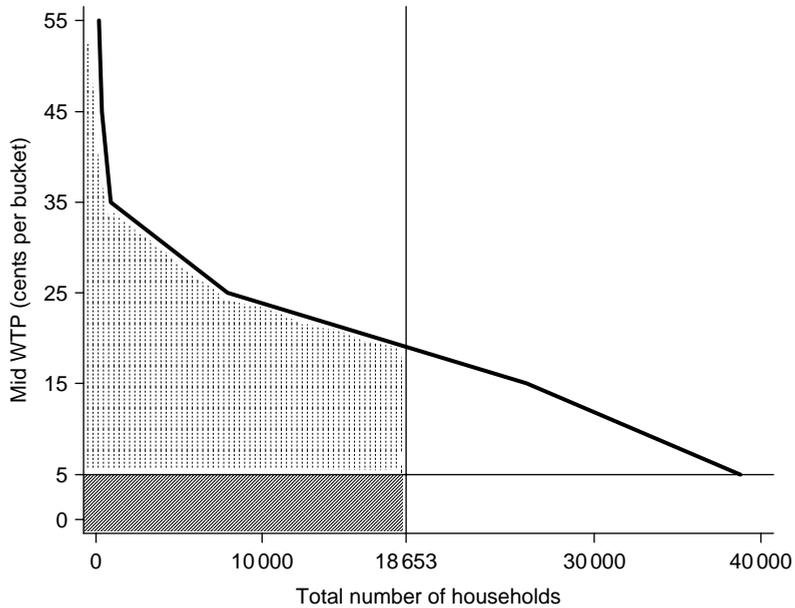| Tabia	No. sample households	Total no. households	Mean WTP per bucket of water (in cents)	Total WTP (in cents)
Adi-Hawsi	32	5,235	20.63	107,998
Hadnet	29	5,328	19.5	103,896
Ayder	30	4,959	12.67	62,831
Hawelti	33	6,429	17.73	113,986
Addis Alem	17	3,673	9.41	34,563
Kedamay Weyane	35	5,542	17.29	95,821
Sewhi Nigus	23	3,878	14.78	57,317
Industry	21	3,731	12.86	47,981
Total	220	38,777	16.2	624,393

Fig. 1. Surplus for currently private tap connected households and revenue for municipality.

In Section 3.2, we reported that among the total 38,777 households in the city of Mekelle, only 18,653 are connected to private taps. Although only the majority of households pay 5 cents per bucket (the lowest price band), we assume here (for simplicity) that all households pay this amount. Under this framework, the number of households currently connected to private taps (18,653 in total) enjoy the
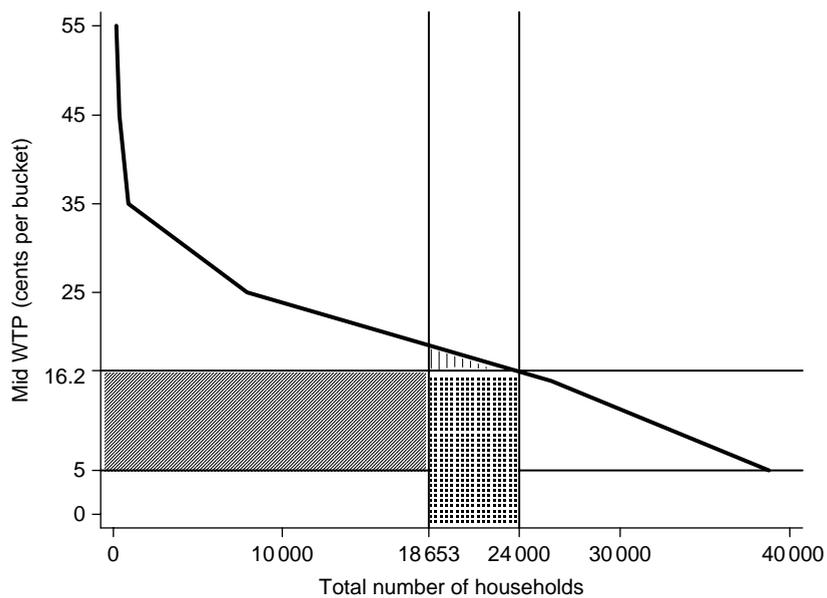

Fig. 2. Gain in surplus and revenue from improved water supply services.

Table 6. Median points of bids vis-à-vis total number of households.

WTP interval (cents per bucket)	Frequency distribution (sample households)		Mid WTP (cents per bucket)	Total no. households	Total no. households paying at least the mid WTP (cumulative frequency)	Total WTP (cents per bucket)
	No.	%				
(0–10)	73	33.18	5	12,866.21	38,777	63,982
(10–20)	102	46.36	15	17,977.02	25,910.79	167,561
(20–30)	40	18.18	25	7,049.66	7,933.77	174,495
(30–40)	3	1.36	35	527.37	884.11	13,573
(40–50)	1	0.46	45	178.37	356.74	8,721
(50–60)	1	0.46	55	178.37	178.37	10,659
Total	220	100		38,777		438,991

surplus equal to the area below the demand curve and above the lowest price band (5 cents) in Figure 1; the municipality collects revenue equal to the area of the rectangle.

For comparison, Figure 2 shows the possible surplus and revenue additionally obtained if the service authorities improve the water supply service. In particular, the figure illustrates that, even if the tariff rate for the improved water supply service is set at the existing maximum tariff (highest band tariff) of 12 cents per bucket (which is lower than the mean WTP estimated value of 16.2 cents per bucket) with supply left unrestricted, there would be a gain in surplus and revenue.

The implication of Figure 2 is that the number of households subscribing to the proposed improved private piped water service will substantially increase. For instance, at the estimated mean WTP amount of 16.2 cents, the number of households who would be willing to pay for the improved service increases to about 24,000 (from 18,653). In the process, households lose the surplus shown by the top rectangle (Figure 2); this loss, however, goes to the municipality as revenue and, from society's point of view, there is no net loss in welfare. On the other hand, however, households gain an additional surplus portrayed by the area of the upright triangle. The municipality, as a provider of an improved water service, also collects an additional revenue (producer surplus) shown by the vertical rectangle. These surpluses were previously not 'tapped', which may be considered as a benefit which society missed (or did not enjoy). Overall, the results from both figures indicate that, as the number of households who subscribe to the improved water service increases, the overall benefit to society rises.

5. Conclusion

In this study, the contingent valuation (CV) method has been employed to analyze the determinants of household valuation of improved water supply service in Mekelle City, Ethiopia. In relation to this, the literature has been lacking some important issues. Previous studies, to our knowledge, ignored selection issues, and are devoid of what should be the 'icing on the cake' of any CV study: the analysis of welfare gains and losses from the proposed improved water supply service. An issue that has received limited attention in the empirical analysis and benefit

aggregation is the treatment of valid responses to the valuation question(s) in general, and true zeros in particular. In this study, we used a censored regression model with sample selection in the empirical analysis of the bid (and selection) models that takes into account the effect of including, and excluding, true zero responses from the least squares method. In this regard, the Heckman Two-Step Estimator has been used. We used the concept of (consumer) surplus and revenue gains to show welfare gains and losses.

Results from the selection models reveal some important implications. The amount of bid that households would be willing to pay is positively associated to household income, ownership of house, price of vended water and the practice of water purification. All these factors encourage households already connected to private taps to pay more for improved water service. While the effect of income and price is consistent with theory, the role of housing status is particularly revealing. The ownership of such a valuable asset in housing is very influential in encouraging households to pay (more) for private tap connections. This is particularly true for households who live in rented compounds where it would be practically impossible for them to have private taps installed, since they do not own the house they live in. One could present the argument that the policy of expanding the condominium houses that the government is currently pursuing may enhance society's welfare, as is shown in Section 4.2. It has been argued that, as the number of households that subscribe to the improved water service increases, there is gain in (consumer) surplus for households and revenue (producer surplus) for the municipality (government). This proposed policy of improved water service expansion is a win-win situation, in that both households and government (society as a whole) gain. Results indicate that even at the estimated mean WTP of 16.2 cents for an improved water service, there are benefits to be reaped as previously unused benefits are realized. Over all, identification of factors that affect the WTP of households for improved water supply service is crucial in formulating a participatory approach under which water utility bodies, households and other major stakeholders can contribute their best to implement the proposed improvement in water supply service and realize welfare benefits which were previously considered as 'dead weight loss'. We urge readers to be cautious in interpreting some of the results of the model (such as the effect of marital status and monthly expenditure); in our study, we could not verify (either by theory or empirical study) the impact of these variables on willingness to pay, and this warrants further research.

Acknowledgements

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