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Water Markets, Demand and Cost Recovery for Piped Water Supply Services: Evidence from Southwest Sri Lanka[1]

Céline Nauges and Caroline van den Berg[2]

In many countries water supply is a service that is seriously underpriced, especially for residential consumers. This has led to a call for setting cost recovery policies to ensure that the tariffs charged for water supply cover the full cost of providing the service. Yet, the question arises how consumers will react to such price increases. We illustrate the impact of price increases on consumption of piped water through a study of the demand for water of piped and non-piped households using cross-sectional data from 1,800 households in Southwest Sri Lanka. The (marginal) price elasticity is estimated at -0.74 for households exclusively relying on piped water, and at –0.69 for households using piped water but supplementing their supply with other water sources, with no significant differences between income groups. Those households that depend on non-piped water sources have a time cost elasticity (as a proxy for price elasticity) of only -0.06. We discuss the implications of these results in terms of pricing policy.

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[2] Céline Nauges is a Senior Research Fellow at the French National Institute for Research in Agriculture at the University of Toulouse. Caroline van den Berg is a Senior Economist at the Energy and Water Department of the World Bank. The opinions reflected in this paper are the opinions of the authors and not opinions of the World Bank, the French National Institute for Research in Agriculture, or the BNWP-WSS.

1. Introduction

An extensive empirical literature exists on residential water consumption in developed countries (see Hanemann 1998, Arbués et al. 2003, or Dalhuisen et al. 2003 for comprehensive surveys). Yet, few such studies exist for residential water consumption in developing countries. Most of the studies on residential water demand are mainly in the form of contingent valuation studies to derive willingness-to-pay for getting a house connection to a piped water network (North and Griffin 1997; Whittington et al. 2002; Pattanayak et al. 2006).

In most developing countries the quality of residential water consumption datasets often pose a problem, especially as metering is not a very common phenomenon. Yet, the market in which utilities operate in many of these countries is also startling different. In contrast to developed countries, where almost all households obtain water from the utility through a piped network, the market for residential water demand in many developing countries shows much more variation. Households may have a connection to the piped network and use exclusively water from their private tap, but they may also combine piped water with water collected from wells, public taps, or purchase water from vendors; or they may have no connection and rely exclusively on non-piped water. Little is known about households' behavior in developing countries regarding the factors driving their choices and in particular the substitution/complementarity relationship between piped and non-piped water for piped households or the combination of non-piped water from different sources for non-piped households. As a result, policy decisions are often not well informed and it is usually assumed that residential water demand in developing countries mimics that of developed countries.

A more detailed knowledge of the structure of water demand of piped and non-piped households in developing countries can help to better understand consumer behavior. For planning purposes, it is essential to be able to predict the change in residential water demand for utility services that will result from any policy that would involve some change in tariffs and/or income for the household. As underpricing of piped water supply occurs often and makes tariff increases necessary to ensure the long-term sustainability of the service provision, understanding how customers might react to such price increases is of importance. Secondly, many households cannot expect to be connected to the piped network in the near future. For these households one may want to make improvements in the non-piped water distribution system to improve access to safe water.

Few studies have estimated residential water demand in developing countries. Using household survey data from 17 cities in Central America and Venezuela, Strand and Walker (2005) derive price elasticities for piped (non-piped) households equal to -0.3 and -0.1 (similar to that of many developing countries). Nauges and Strand (2005), using the same dataset, estimated water demand of non-piped households in four cities in El Salvador and Honduras, where the vast majority of the surveyed households relied on one water source only (private tap, public tap, public well, or truck). They found non-tap water demand elasticities with respect to total water cost (defined as the sum of water price and collection time costs) of between –0.4 and –0.7. Basani et al. (2004), using cross-sectional household-level data from seven provincial Cambodian towns, estimated the price elasticity of water demand of connected households to lie in a range between -0.4 and -0.5. Rietveld et al. (2000), using data from Indonesia, found a price elasticity for connected households of -1.2.

The present paper contributes to this literature by providing an empirical analysis of the water demand function of piped and non-piped households from Southwest Sri Lanka. Data come from a survey of 1,800 households conducted in August-October 2003. Section 2 describes the background and data. In section 3, we discuss the specification of the water demand models and estimation strategy. Estimation results are described in section 4, while policy implications and conclusions are found in section 5.

2. Background and data

The population of surveyed households covered three districts in Southwest Sri Lanka: Gampaha, Kalutara and Galle. The survey was undertaken to support the design of two private sector transactions in this part of Sri Lanka which the then Government of Sri Lanka (GoSL) was proposing: one for the town of Negombo, north of Colombo, and one stretching along a coastal strip south of Colombo, from the town of Kalutara to the town of Galle. The population in these two service areas in 2001 was slightly more than 1.6 million[3].

[3] The total population considered in the Greater Negombo service area was about 367,000, while the service area covered by the coastal strip from Kalutara to Galle had a total population of 1,254,000 in 2001.

The survey data are rather unique. Because of widespread metering of households with a piped water connection, the consumption data have a high degree of accuracy that is not often found. In addition, the dataset is complemented by a large set of socio-economic and health variables.

2.1. Piped households

Among the surveyed households, 38 percent had a private connection to the piped network (for further purposes of the study, we removed from the sample the 84 households who did not report any monthly water use). Of the households with a private connection 23 percent had an in-house private connection, 19 percent had (only) a yard connection, and 58 percent had both. Piped households consume on average about 135 liters of water per capita per day from the piped network.

Piped households had to pay SLK 8,415 (equivalent to US$87 in 2003) in order to get a private connection to the piped network (including road cutting, pipe laying, meter installation). This represents about half of the monthly wage for a piped household.

Water from the piped network is charged through an increasing five-block tariff. The same tariff applies to all piped households in our sample. Marginal price varies from SLK 1.25 per cubic meter in the lowest block (for any unit below 10 cubic meters per month) to SLK 45 per cubic meter for any unit above 25 cubic meters per month. Households are almost equally distributed across the five blocks.[4] The water bill, which includes a fixed fee of SLK 50, is sent every month to each household connected to the piped network. The typical or median monthly water bill is SLK 89, while a typical household spends SLK 10,300 on household expenses – suggesting that the costs of piped water supply makes up less than 1 percent of household expenditure. The typical water bill for the poor (defined as a piped household with an income falling in the first quartile of the income distribution) is SLK 72 (which represents about 1 percent of household expenditure).

Piped households have been asked to give their opinion about the quality of the piped water service. Overall, 25 percent of households with piped water declared themselves to be

[4] Block 1: [1-10 m^3], price is 1.25 SLK/m^3; block 2: [11-15 m^3], 2.50 SLK/m^3; block 3: [16-20 m^3], 6.50 SLK/m^3; block 4: [21-25 m^3], 20.00 SLK/m^3; block 5: [>25 m^3], 45.00 SLK/m^3 .

satisfied with the service. The most frequent complaint is about piped water being available less than 24 hours a day (41 percent of households), followed by complaints about frequent breakdowns (9 percent of households), too high a monthly bill (5 percent of households), and poor water quality (3 percent of households). Piped water availability varies across households. In the rainy (dry) season, 31 percent (22 percent) of piped households have a 24 hour service of piped water; 36 percent (42 percent) have access to piped water for 12 hours or less; 10 percent (13 percent) for 6 hours or less. Non-continuous piped water service may be one of the reasons why some piped households get water from other (i.e., non-piped) sources in the neighborhood.

Among the piped households, almost 95 percent have access to other water sources, namely public taps (112 households), public wells (172), private wells (352), neighbors (492), vendors (31), rainwater (93), surface water (76) or bottled water (396). As can be seen from this list, many piped households have access to more than one additional source. Despite the widespread access to other sources, only 40 percent of piped households use water from other sources, mostly from private wells. Piped households (who also get water from other sources) consume on average 10 cubic meters per month from these sources (Table 1).

Consuming non-piped water imposes different types of "costs" on a household, when compared to using the water directly from their private tap. First, the household may spend time to go to the source and wait at the source to obtain the water. Secondly, water from most non-piped water sources in general involves collection costs (the household may need to buy equipment to abstract the water such as a hand pump or an electric pump). Thirdly, the household may need to pay a fee to get access to the water, in particular if bought from vendors or community sources. Finally, there is the inconvenience of not having access to piped water as such, including a possible lower quality of the non-piped water.

In our sample, walking time for piped households who collect water from a private well or from community sources is on average less than 5 minutes, whatever the source (Table 1). The shortest walking time is observed, as expected, for those households who get water from a private well. Only households collecting water from public taps have to wait at the source (7 to 8 minutes on average). Public wells are all of the "dug well" type; private wells are too, although in a small number of cases (12 percent) they are of the "tubewell" variety. Households who collect water from wells have to buy equipment to collect water. The most common equipment is a bucket and rope (as expected from the prevalence of dug wells) followed by hand and electric pumps. Households relying on public (private) well spend on average respectively SLK 2,600 and SLK 13,600 to buy the necessary equipment. Operating costs for households collecting water from public (private) wells represent on average respectively SLK 10 and SLK 34 per month. Households in our sample do not pay any fee for buying non-piped water, whatever the source, but they do pay for installing equipment to obtain access to the source of water.

Households were also surveyed regarding water treatment and hygiene practices. Overall, 45 percent of the piped households declared to treat or filter water before drinking it (see Nauges and van den Berg 2006, for a detailed analysis of risk perception and hygiene practices).

2.2. Non-piped households

About 62 percent of the households in the sample do not have any piped connection. Among them, 98 get water from public taps, 102 from public wells, 313 from their neighbors, 967 from private wells, 11 from vendors, 29 from surface water, 8 collect rainwater, and 8 buy bottled water. Some households combine water from different sources. The most frequent combination of water sources among the surveyed households is neighbors with private well, public tap with private well, and public well with private well.

Households relying on private wells consume on average 759 litres per day, more than twice the amount of water collected on average from community sources: public wells (367 litres), neighbors (243 litres), and public taps (119 litres). The average one-way walking time to go to the source varies between 1 (for accessing a private well) and 6 minutes (public wells). Waiting time at the source varies from none (private well) to 24 minutes (public taps). The cost of installing (operating) equipment to collect water from wells is SLK 6,600 (or SLK 36 per month) on average for households using public wells and SLK 15,400 (or SLK 67 per month) for households using private wells (Table 2).

Most public wells (91 percent) are of the dug well type. A vast majority of households relying on public wells (86 percent) collect water using a bucket and rope, 7 percent uses a hand pump, and 4 percent an electric pump. The picture is different for households relying on private wells. A smaller percentage – albeit still the large majority – of private wells (76 percent) is of the “dug well” variety. Most households with a private well use pumps: 47 percent an electric pump, 10 percent a handpump and the remainder buckets and ropes to abstract the water.

Overall, non-piped households are satisfied with the non-piped water. More than 80 percent of households collecting water from public taps, neighbors, and private wells judge the taste of water as excellent or good (in the rainy season). The percentage of households satisfied with the taste of water is slightly lower among households relying on public wells (52 percent). As far as safety of the water is concerned, 90 percent of all households relying on public taps, neighbors, and private wells think that there is no risk or little risk in drinking the water. This percentage is again lower for households collecting water from public wells (60 percent).

Households’ confidence about non-piped water safety is confirmed by the fact that only 40 percent of non-piped households treat or filter their water before drinking it (this percentage is higher among the group of piped households). There is no significant difference across sources.

Descriptive statistics on household demographics and socioeconomics, and water treatment are presented in Table 3, for both non-piped and piped households. Mean comparison tests show that piped households in general are characterized by having more household members, higher income, and higher education than non-piped households.

3. Specification and estimation procedure

We estimate separate water demand models, one for piped water and the other one for non-piped water, as quality of the water from the piped network may differ from quality of water collected from a private well or from community sources. Consistency of estimation techniques relies on the randomness of the samples considered. Yet, because it is likely that the households’ characteristics for the two groups are different, we have to control for selection bias by first estimating a model that explains the differences between households that have or do not have a connection to the piped network.

3.1. Determinants of the connection status

The discrete choice model is specified as follows: the discrete variable (d_i) takes the value of 1 if the household has a private connection to the piped network and 0 otherwise. We assume that this decision is the outcome of a latent model of indirect utility maximisation by the household. Under the assumption of normality of the error term u_1, the decision model takes the form of a Probit model.

(1) $$\Pr(d_i = 1) = \Pr(x_{1i}\beta_1 \prec u_1) = \Phi(x_{1i}\beta_1)$$

where $\mathbf{x_{1i}}$ is the vector of explanatory variables in the latent model, and β_1 is the vector of associated parameters.

Getting a private connection may be quite expensive for some households (about LKR 8,500), so we would expect low-income households to less likely have a connection. Also, we would expect that households that have easy access to other sources and in particular households owning a private well are less willing to pay for a private connection to the piped network. We also control for the role of household demographics and socioeconomics (household size, income, education) and opinions about water quality.

Note that we use contemporaneous variables to explain a decision which could have been taken years before – we do not know when piped households got the private connection to the water network. We thus need to assume that the explanatory variables that we use have not changed “too much” after getting the connection. This is likely to be the case for variables such as education of the head, and access to other sources. This may not be true for income and opinion about water taste and safety.

We will compute Mill’s ratio from the estimated parameters. This ratio will be added to the water demand models to control for selection bias (Heckman, 1979):

(2) $$M_i = \phi\left(x_{1i}\hat{\beta}_1\right) \Big/ \left[1 - \Phi\left(x_{1i}\hat{\beta}_1\right)\right],$$

where $\phi(.)$ is the standard normal probability density function and $\Phi(.)$ is the cumulative of the normal distribution.

3.2. Water demand of piped households

The water demand function of the representative household connected to the piped network is traditionally specified as a single equation of the form:

$$(3) \qquad W^P = f^P(P^P, I, Z)$$

describes the relationship between piped water consumption (W^P), the price of piped water (P^P), household income (I), and a vector of household characteristics (Z) to control for heterogeneity of preferences and outside variables affecting water demand.[5] This approach, which provides a satisfactory description of the behavior of piped households collecting water from their private tap only, does not allow to measure substitutability/complementarity relationship between piped and non-piped water for those households who combine water from the piped network with water from other sources such as private or public wells, vendors, or get it from their neighbors. In the latter case, a simultaneous two-equation model is better suited. A two-equation model also allows one to consider piped and non-piped water as two different goods, with different organoleptic (smell, taste, colour) and sanitary properties. For households combining piped water with non-piped water, we thus specify the model as follows:

$$(4) \qquad \begin{cases} W^P = f^P(P^P, P^{NP}, I, Z) \\ W^{NP} = f^{NP}(P^{NP}, P^P, I, Z) \end{cases}$$

where W^{NP} and P^{NP} represent non-piped water consumption and non-piped water price, respectively.

In our sample, about 40 percent of piped households combine water from the piped network with non-piped water, the latter being essentially a private well. We estimate separate water demand models: a single-equation model (see equation (3)) for piped households using piped

[5] The Mill's ratio will be added to the list of regressors to control for potential selection bias.

water only, and a two-equation model (see model (4)) for piped households combining water from the piped network with non-piped water.

Explanatory variables in water demand models commonly include water price, income, and household demographic and socioeconomic characteristics. Some discussion is needed here regarding the specification of the price variable for piped and non-piped water.

For all households in our sample water from the piped network is sold under the same five-block increasing tariff, and all piped households have to pay a fixed fee of SLK 50, whatever their monthly consumption. Homogeneous pricing in our sample makes it impossible to estimate water demand using the (consistent) two-step approach describing the choice of the block (first step) and the choice of consumption inside the block (second step), see Hewitt and Hanemann (1995). We estimate a linear demand equation in which the price variable is instrumented to control for endogeneity.

The specification of the price variable in the case of non-linear block pricing has been extensively debated during the last 30 years (see Espey et al. 1997, Arbués et al. 2003, and Dalhuisen et al. 2003, for related discussions). If theory advocates the use of marginal price (the price of the last cubic meter), average price (computed as total bill divided by total consumption) has however often been preferred. Authors considering average price argue that households are rarely well informed on the price structure and are thus more likely to react to average price than to marginal price.

In the present study, one could argue that average price should be chosen because the water tariff structure is quite complex (it is made of five different blocks, and the fixed fee makes up a large part of the total cost especially for lower-volume users) and so households are less likely to know in which block they are and which marginal price will be charged to them. However, it is also very well possible that households know the marginal price because the price in each block varies significantly (from SLK 1.25 per cubic meter in the low block (for any unit below 10 cubic meters per month) to SLK 45 per cubic meter for any unit above 25 cubic meters per month), and widespread occurrence of metering assumes that households have (some) control over their consumption.[6]

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[6] Distribution graphs of households inside each of the five blocks show that households in the first four blocks tend to choose the "right-end" of the block, while households in the fifth block are gathering around the "left-

We test which price households are sensitive to using Shin's price perception test (1985). Shin proposed to introduce in the demand model the following variable:

(5) $$MP_i \left(\frac{AP_i}{MP_i} \right)^k$$

where *MP* and *AP* stand for marginal price and average price, respectively, and *k* is called the perception parameter. If the consumer responds only to marginal price, then $k=0$, and if the consumer responds only to the average price, then $k=1$. If the consumer's perceived price lies between the average price and the marginal price, then $0<k<1$.

As explained before, marginal price and average price are, by construction, endogenous in the demand model, and have to be instrumented. Because the same tariff structure applies to all households (i.e., there is no cross-sectional variation), it is not possible to use the price of each block and the quantity limiting each of the blocks as instruments for the marginal and average prices. Instead, we choose as instruments some households' characteristics: income, household size, number of rooms in the house, access to other sources, type of connection (yard, in-house), use of a storage tank. Predicted values for the marginal and average prices are then used to build Shin's perception variable.[7]

Costs borne by households collecting water from private wells or community sources have already been discussed (see section 2.1.). All surveyed households in our sample do not pay for the daily consumption of non-piped water, whatever the source (public tap, public well, neighbors, etc.); vending of water tends to be virtually non-existent. However households collecting water from these sources have to spend time to go to the source and to wait at the source. One should in theory compute an opportunity cost of time, which would correspond to the (monetary) value of the time spent to get the water for the member of the family in charge of it. Information on who goes to the source is sporadic in the survey[8] and difficult to use. We will thus consider in demand models total time (in minutes) spent to go to the source and to

end" of the block. Such behavior would be more consistent with a "marginal price perception", since households (in the first four blocks) seem to consume "up to the limit" once they have selected the block of consumption.

[7] Another possible approach to instrument marginal price could be based on the probability of each household's consumption to fall in each of the five blocks (see Mansur and Olmstead, 2005).

[8] The person in charge of collecting water is in most cases not identified.

wait there. We believe that using total time instead of the opportunity cost of time is acceptable in this case as the average time spent to go and collect the water is quite short (less than five minutes on average). Households who collect water from private or public wells need some equipment such as, for example, a bucket and rope, a hand pump, or an electric pump. Households were questioned about the cost of the equipment, including capital cost and monthly operating costs. Capital costs and operating costs are largely fixed costs, i.e., they have to be incurred by the household whatever his monthly consumption.[9] These costs will be used in the demand model as a proxy for the value of the capital owned by the household. Since more sophisticated equipment is in general more costly, we expect that the higher the fixed costs, the more convenient it is to collect water, and the higher the consumption by the household should be. We compute the monthly equivalent of the capital cost as follows:

$$I \times \frac{r(1+r)^m}{(1+r)^m - 1} \tag{6}$$

where I is the cost of the equipment, r is the monthly interest rate at which household can borrow money, [10] and m measures the longevity of the equipment (in months). We assume that a pump has a longevity of 7 years on average.

3.3. Water demand of non-piped households

Water demand of non-piped households will be analyzed using two different approaches. The first one will assume that non-piped water is of comparable quality across sources and we will study the overall non-piped water demand, i.e., we will aggregate, for each household, water collected from different non-piped sources. The second approach will focus on those households combining sources in order to study more precisely the substitutability and complementarity relationship between the combined sources.

In both models, right-hand side regressors will include time cost (to go to and to wait at the source), capital costs if the household has invested in some equipment to collect the water (see the discussion about computation of time and capital costs in section 3.2.), households demographics and socioeconomics.

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[9] We do not know if the household had to borrow money to get the equipment and whether or not he is still paying back the equipment.

[10] Households were questioned about the interest rate that they would have to pay if they could borrow money from a lender.

We will assume all along that the sources households have access to, are exogenous in the water demand model.

4. Estimation results

To avoid extreme values in the distribution of water consumption per capita, we cut the distribution (of total water consumption per capita) above the 5th percentile and below the 95th percentile. Note also that because of missing information for some of the variables, the total number of observations used to estimate the various models may be different from one model to the other.

4.1. Determinants of the connection status

Maximum-likelihood estimation results for the Probit model describing household's connection status are presented in Table 4. We present here the best fitted model. The following regressors were finally kept in the model: income (includes estimated total monthly income of all wage earners in the household, plus any other source of income, plus any money that is remitted to the household by a family member working outside the country), household size, number of years of education completed by the head of the household, access to a private well, access to community sources (includes access to public taps, public wells, vendors, surface water, and rainwater), dummy variables for district, and dummy variables measuring concern about taste, reliability, and safety of water from private wells.[11] The model is estimated on the full sample (1,794 households).

Overall fit of the model is satisfactory, providing 79 percent of correct predictions. Estimated coefficients are almost all significant and have the expected sign. Households receiving a higher income and households with a more educated head are more likely to have a private connection. Access to other (non-piped) water sources, and in particular to a private well, significantly decreases the probability to get a private connection. Household size is not found significant in this model. Finally, the three dummy variables describing concern about taste,

[11] Households were questioned about their opinion regarding taste, safety, and reliability of water from each source. From their answers, we build three indicator variables which take the value of 1 if households are concerned about taste, safety, and reliability of water from their private well, and 0 otherwise.

safety, and reliability of water from private well have all the expected positive sign: the more concerned the household is about water quality from the private well, the higher the probability that she gets a private connection to the piped system. Taste appears to be the primary concern (highly significant), followed by reliability (significant at the 10 percent level), and then by safety (non-significant).

From the estimated parameters we compute the Mill's ratio which will be added to the water demand models to control for potential selection bias.

4.2. Estimation of water demand of piped households

a. Instrumentation of marginal and average prices

We estimate two models, the first (second) model with marginal price (average price) as the dependent variable. In the two models the set of regressors include: household size, income, number of rooms in the house, a dummy variable taking the value of 1 if the household has access to any (non-piped) water source and 0 otherwise, a dummy variable taking the value of 1 if the household has a yard connection only (i.e., no in-house connection) and 0 otherwise, a dummy variable taking the value of 1 if the household has a storage tank and 0 otherwise. Ordinary Least Squares estimation results are not reported here, but are available from the authors on request.

b. Estimation of the water demand equation of piped households using only water from the piped network

We estimate a single demand linear equation on the sub-sample of households who get water from the piped network only (299 households).[12] The dependent variable is the log of piped water use per capita per month (measured in cubic meters). Different sets of regressors and different specifications have been tried but we present here the model which yields the best fit to the data. Estimation results are shown in Table 5.

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[12] Specification tests have shown that selection bias is not an issue when considering separately piped households relying on piped water only and piped households combining water collected from the piped network with water collected from other sources. Results are not shown here but are available upon request.

Our model being of the log-log form, Shin's price variable is decomposed into two terms. We estimate the following water demand model:

(7) $$\ln(W_i^P) = \alpha_0 + \alpha_1 \ln(MP_i) + \alpha_1 k \ln(AP_i / MP_i) + \delta' X_i + \varepsilon_i$$

where the X_i-vector gathers all regressors except price variables. In this model, α_1 is the coefficient of the perceived price and $\alpha_1(1-k)$ is the coefficient of the marginal price (Shin, 1985).

The perception parameter k is found equal to 0.02 (calculated as the ratio of -0.0176/-0.7430), which, following Shin (1985), corresponds to a "marginal price perception". Marginal price elasticity is estimated at -0.74 (significant at the 10 percent level) in this model. A 10 percent increase in marginal price would induce a 7 percent reduction in per capita residential water consumption. This estimate is in-between what was found by Strand and Walker (2005) on data from Central America and what was derived by Rietveld et al. (2000) using data from Indonesia.

Income elasticity is estimated at 0.10 (significant at the 5 percent level). The relatively high price elasticity may be due to the availability of alternative water sources, and possibly the use of an increasing block rate structure (Olmstead et al. 2003) and households' access to price information (Gaudin, 2006).

The coefficient of household size is not found significant. Households living in a house with a greater number of rooms use on average more water per capita. Households who get more convenient access to piped water through increased water pressure (presence of a storage tank) and who enjoy piped water for a greater number of hours of supply, consumes on average more water per capita. Having a storage tank in the house is found to increase monthly per capita consumption by 22 percent on average.[13] An extra hour of piped water availability would increase monthly per capita consumption by 0.4 percent (not significant in this model). Having a yard connection only (and no connection inside the house) decreases monthly water consumption per capita by 22 percent, all other things equal. If introduced in

[13] Having a storage tank increases the log of per capita consumption by 0.1995 cubic meters. This corresponds to an increase in per capita consumption of [exp(0.1995)-1]=0.22 or 22 per cent.

the vector of explanatory variables, the dummy indicating that the household has two connections (in-house and private) does not come out significantly. In other words, having the two types of connection does not increase the overall consumption from the piped network, all other things equal. We keep in the model the 3 (over a total of 15) municipality dummies that are significant (Galle Four Gravets, Katana, and Negombo). We also considered some other explanatory variables such as education level or household's opinions about piped water service (see a discussion of these variables in section 2.1.). None of these variables have a significant influence on water consumption per capita. The survey also includes data on house assets (kitchen assets, toilets) and materials used for building the house. Most of these variables were collinear with income and, for that reason have been taken out of the demand equation.

The above model has been specified under the assumption that households have identical preferences, in particular that price elasticity is the same across households. Such an assumption can be tested by allowing the parameters of the price variable to vary across groups of households. We test whether price elasticity varies across income groups. We allocate households into five groups, based on household monthly wage. Group 1 gathers the "poorest" households, i.e., households who fall in the first quintile of the income distribution, group 5 gathers the "wealthiest" households, i.e., households who are in the fifth quintile of the income distribution. We re-estimate the same model allowing price elasticity to vary across the five income groups. The five coefficients are found to be negative, varying from –0.55 in the third income group to –0.60 in the second. Estimates are quite imprecise (standard error is about 0.28) and coefficients are not proved statistically different from one income group to the other. We also tested whether income elasticity was different across income groups. In this case also, statistical tests could not reject the null hypothesis that income elasticities are equal.

c. Estimation of the water demand equation of piped households combining piped water with non-piped water

We estimate a simultaneous two-equation model, the first one for water consumption from the piped network, and the second equation fitting non-piped water consumption. In both equations the dependent variable is the log of water consumption per capita per month, measured in cubic meters.[14] Estimation is made on the sub-sample of 206 piped households who combine water from the piped network with water from other sources. In order to control for possible selection bias, Mill's ratio derived from the estimation of the discrete choice model describing the relationship between households' characteristics and connection status (see section 4.1.) is included in the two equations as an additional regressor.

Shin's test reveals that households perceive marginal price rather than average price. We use the (log of) instrumented marginal price. The price for non-piped water is measured by the (log of) time cost to collect water (measured in minutes). Estimation results are presented in Table 5.

Estimated own price elasticity for piped water consumption is -0.69 (significant at the 1 percent level), which is in the range of price elasticity estimated for piped households relying on piped water only. Price elasticity of piped residential water demand is thus found to be the same across the population of piped households, whether they collect water from other sources does not matter here. Interestingly, the expected marginal price is found to have a significant and negative (but lower in magnitude) impact on non-piped water consumption as well. An increase in the price of piped water induces a lower consumption of both piped and non-piped water, showing that households do not substitute non-piped water to piped water when the price of piped water increases. Time cost is significant in both models, and the signs illustrate the substitution between piped and non-piped water. The shorter the time needed to walk to the source and to wait at the source, the higher the consumption of non-piped water, and the lower the consumption of piped water. In other words, the more convenient access to non-piped water for piped households, the more they substitute piped water with non-piped water.

Income elasticity is significant (at the 15 percent level) in the first equation only, estimated at 0.11. Households having a private connection in the yard on average consume less piped water.[15] Again, the longer the time piped water is available, the higher the consumption from the piped network, and the lower the consumption of non-piped water. An extra hour of piped

[14] Households were questioned about the total amount of water collected from each source (in litres per day). We assume that they go to the source every day and we compute accordingly the equivalent non-piped consumption in cubic meters per month.
[15] In this model also the dummy variable equal to 1 if the household has two connections (in the house and in the yard) did not come out significantly.

water availability is found to increase consumption from the piped network by 2 percent and to decrease non-piped consumption by 1.8 percent on average. Ownership of an electric pump increases non-piped water consumption by 98 percent on average, and decreases piped consumption by 34 percent. Note that using operating costs instead of the electric pump dummy variable would yield qualitatively the same results (the higher the operating costs, the more sophisticated the equipment, the easier the collection of non-piped water, the higher the consumption of non-piped water). We also included two dummy variables equal to 1 if the household main concern was about the taste of non-piped water and the safety of non-piped water. These variables were not found significant in any of the demand models. Mill's ratio is significant (at the 10 percent level) in the second equation, showing that it is important to control for the household's connection status. Note that we also tested for significance of education level and the cost of the private connection. None of these variables were found significant.

The Breusch-Pagan test rejects (at the 10 percent level) the null hypothesis that residuals from the two equations are independent. A simultaneous estimation of the system is thus a necessary condition to get efficient standard errors.

On the one hand, the above analyses show that price and income elasticities derived for piped households are similar to developed countries in the sense that they confirm a low price elasticity of water demand (i.e., a price elasticity which is less than one in absolute terms) and a positive but rather small income elasticity (about 0.10). On the other hand, they provide new evidence about the behavior of piped households who combine piped water with non-piped water. We show that non-piped water (which is judged good and safe by a vast majority of the surveyed households) is used as a substitute for piped water especially when the latter is not easily accessible (because the connection is in the yard and not in the house) and/or when there is not a continuous service from the piped network. Piped households are found to substitute more piped water with non-piped water when they are closer to the alternative source (i.e., less time is required to collect water or they own a private well), and when they own more efficient equipment to collect water (i.e., less effort is required to collect the same amount of water).

Overall, these results show that households value the convenient access to reliable and safe water positively, whether it comes from the piped network or they get it from their private well does not seem to be of primary concern. It confirms in a sense what was found in hedonic analysis of property prices measuring the value of a water connection in Central America by Nauges et al. (2005). These authors show that a private well on one's property is valued as much as a connection to the piped network, by non-connected households.

4.3. Estimation of water demand of non-piped households

a. Estimation of aggregated non-piped water demand

We consider the whole sample of non-piped households (1,004 households). We estimate a single equation model where the dependent variable is the log of non-piped water consumption per capita (measured in litres per day). If some non-piped household combines water from different sources, we aggregate consumption from these sources. We assume that the quality of water is the same across sources. We do control to which source each household has access to by introducing four dummy variables equal to 1 if the household has access to water provided by neighbors, a private well, a public well, or a public tap, respectively.[16] Specification tests have been made in order to determine the "best" set of regressors. Estimation results are shown in Table 6.

The value of capital or total value of the investment (as measured by the sum of the monthly equivalent of capital cost and monthly operating cost) made by the household in order to collect water is highly significant in this model. The higher the value of the equipment purchased to source non-piped water, the more convenient to collect non-piped water, the higher per capita non-piped water consumption is. Time cost has the expected negative sign and is also significant at the 1 percent level: the more time needed to go to and to wait at the source, the lower per capita consumption. It is interesting here to note that time spent to collect water, which may seem low on average, has a very significant effect on consumption. Income elasticity is rather small (0.07) but significant at the 10 percent level. In this model, household size is found highly significant and the negative sign of its coefficient illustrates the so-called scale effects (the larger the family, the lower per capita consumption). A bigger house and the possibility to store water (although the latter is not significant) are found to increase per capita water consumption. The variables measuring concern about taste have an

[16] We do not include any dummy variable to control for access to other sources such as vendors, surface water, and rain water, as these sources are used by very few households in our sample.

expected negative sign but are not found significant in this model. The non-significance of the Mill's ratio shows that there is no bias due to possible selection problems.

The single equation approach however does not take into account that water from different sources may be of different quality, and does not make possible identification of any substitutability/ complementarity relationship between water collected from different sources. We then estimate a two-equation model, focusing on households combining water from different sources. Illustration is made using the sub-sample of non-piped households who combine water from private wells with water provided by neighbors, since the number of observations is high enough to permit identification of most of the parameters.[17]

b. Estimation of water demand of households combining water from private well with water provided by neighbors

Estimation is made on a sample of 161 households. The four coefficients measuring the impact of the cost of time on water consumption are significant in this model (see Table 6). The negative time cost elasticity and the positive cross time cost elasticity illustrate substitution between water from the private well and water provided by neighbors: the more time needed to get water from a source, the lower the consumption from that source and the higher the consumption from the alternative source. Income elasticity (about 0.20) is found significant in both equations. Its value is slightly higher than income elasticity estimated in the previous model describing aggregate water consumption of non-piped households. Household size is highly significant in the two equations. Again, the negative coefficient illustrates scale effects in water use. The size of the house has a positive and highly significant effect on water consumption from the private well. Being able to store water does not have any significant effect on water consumption, whatever the source (i.e., private well or water provided by neighbors). The variables measuring complaints of households about taste are not found significant in any of the equations, probably because a vast majority of non-piped households collecting water from private well or getting water from neighbors declared to be satisfied of water quality. The use of an electric pump in the equation fitting water consumption from private well is not significant. In the second equation, households are

[17] We estimated the system of demand equations for non-piped households combining water from public tap with water from private well, and for non-piped households combining water from public well with water from private well. Because of the low number of observations (62 and 46 respectively), most of the parameters were not found significant. Estimation results are not shown here.

found to have, on average, a higher per capita consumption when neighbour provides access to a private well (instead of providing access to a tap connection). The latter is significant at the 20 percent level. For the first time, we find a significant effect of the variables indicating ethnicity. Sinhalese households are found to have a significantly lower per capita consumption from private wells, all other things equal. Mill's ratio is not significant in this model.

5. Conclusions and policy implications

Using data from a survey of 1,800 households in Southwest Sri Lanka in 2003-2004, we estimate water demand functions of piped and non-piped households.

The analysis leads us to five findings. First, the (marginal) price elasticity of households exclusively relying on piped water is -0.74. Even though these households only use piped water, their access to alternative water sources tends to be high. On average, households who only use piped water have access to 1.8 alternative sources of water (the most frequent alternative source being access through neighbors), while piped households who combine piped and non-piped water have access to 2.4 alternative sources of water (private well being the most prevalent non-piped source). The value of the price perception parameter in the models that captures the effect of the tariff structure on the demand for piped water is close to zero. This means that households tend to respond to the marginal price, and suggests that consumers tend to be well-informed about the price of piped water despite the relative complexity of the tariff schedule. Widespread metering enables consumers to exercise control over their consumption. As a result, the majority of households using piped water consume less than 20 cubic meter per month – this is a level of consumption at which water tariffs are highly subsidized (see footnote 4).

Secondly, the price elasticity of households using piped water but supplementing their supply with other water sources shows a price elasticity of -0.69. The cross elasticity of alternative water sources (as measured in time costs) is 0.08. Alternative water sources are hence considered substitutes for piped water. Due to insufficient data to translate time costs into monetary cost of water, it is not possible to determine the precise level of substitution between piped and non-piped water. It seems that piped water supply is valued in terms of reduced time costs and hence convenience. Yet, the relatively low value of the cross elasticity could be an indication that the different water supply sources are considered as different "services or products". The demand for non-piped water for households that also use piped water shows a time cost elasticity of -0.34, and a cross elasticity of piped water of -0.37. The negative sign of the cross elasticity shows that the demand for non-piped water decreases when the price of piped water increases, suggesting that non-piped water supplies for households using both types of water sources are complementary goods instead of substitutes.

Thirdly, for households that use piped water, price elasticity is not statistically different between different income groups. Households will reduce their consumption when tariff increases are implemented, but there is no difference in how they react, due to the rather similar consumption patterns between poor and non-poor households, and the fact that water expenditures make up only a very small portion of their household budgets. This finding seems to undermine the basic assumption that underlies many increasing block rate schedules, including the one used in Southwest Sri Lanka. Therefore, the possibility to cross-subsidize poor consumers by charging higher rates to non-poor households is a strategy that has only limited potential.

Fourthly, income elasticity is positive but very low – comparable to results of previous studies in developing and developed countries. For piped water consumers, income elasticity is estimated at about 0.10. In addition, statistical tests showed that income elasticity does not differ between income quintiles – suggesting that piped water consumption patterns between income groups are rather similar. Because of the low income elasticity of residential consumers, which form the bulk of the utility's consumers and revenues, the potential of a sharp increase in consumption volumes and hence utility revenues through internal growth from existing customers is therefore limited. The low income elasticity shows that consumption volume is not a very good proxy for income. As such, consumption blocks as used in the current tariff structure in this part of Sri Lanka are not a very good instrument for targeting subsidies to the poor.

Finally, those households that depend on non-piped water sources have a time cost elasticity (as a proxy for price elasticity) that is only at -0.06 for all non-piped households. Yet, households using different types of non-piped water are experiencing different time cost elasticities. Households using private wells have a time cost elasticity of -0.10, while those using water provided through neighbors have an elasticity of -0.34. These values are consistent with households using neighbour water spending more time hauling water compared to for instance private well water. Income elasticity is higher at 0.20 for households using private wells or water provided through neighbors, as households that depend on non-piped water, especially other sources than private wells, tend to consume less water than those households that depend on piped water.

In Sri Lanka, as in many other developing countries, the utility is charging tariffs that are substantially below the full cost of service. The lack of cost recovery results in low quality services and lack of expansion of the network. In Southwest Sri Lanka, large tariff increases would be needed to ensure that the water utility can recover its full costs and expand its network in the long run. Tariff increases will result in a growth of the utility's revenues, but its positive impact on revenues will be relatively modest due to the high value of the price elasticity. Even though households attach value to the convenience of piped water, the value they attach to such convenience is unlikely to ensure full cost recovery of piped water services in the short run. The low income elasticity suggests that the growth in revenues without a corresponding increase in the number of new consumers will be relatively small. Yet, the easy access to alternative water sources dampens the demand of non-piped water consumers for piped water services as is shown in Pattanayak et al. (2006) with low uptake rates for non-piped water consumers for improved piped water services. The interesting point is that in this particular case, the relatively high price elasticity and low income elasticity magnify each other making it more difficult to achieve cost recovery of piped water sources. In such cases, where full cost recovery is likely not to be achieved in the short to medium term, subsidies are likely to be needed, especially if the poor are to benefit from piped water service delivery. To the degree possible, the size of such subsidies should be reduced by reducing the cost of the service through improvements in operational and capital efficiency, revising technical standards against which the service is delivered (see Yang et al., 2006).

The availability of alternative water sources puts downward pressure on the value of piped water in Southwest Sri Lanka. This is the result of a water supply market that is characterized by providers offering relatively similar, but not perfectly substitutable water services as these services tend to differ in terms of service level, convenience and the time needed to get serviced. In such an environment, full cost recovery of piped water is not easy to achieve, and long-term subsidization of piped water services will be necessary to ensure the financial sustainability of such services. Yet, as more non-poor consumers tend to be serviced by piped water, and subsidization of such utility services will remain needed in the foreseeable future, the combination of easy availability of alternative water sources and subsidized piped water services for an essentially non-poor customer base raises concerns about the use of public funds. As poor customers depend more likely on unsubsidized water, often non-piped, services, and subsidies for piped water tend to be mostly benefiting non-poor customers. Hence, in this particular environment where the public health benefits of piped water tend to be relatively small, the equitable use of public funds might be better used to focus government funded investments on those types of investments that have a higher rate of return for the poor.

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Tables

Table 1. Access to and use of non-piped water by households connected to the piped network.

	Public tap	Public well	Neigh-bours	Private well	Vendors	Other surface water	Rain-water	Bottled water
No. of piped households								
with access to…	112	172	492	352	31	76	93	396
using water from…	2	10	32	184	1	2	-	2
Water consumption from piped network (m^3 per month)								
Mean	8	14	14	16	18	28	-	33
Median	8	14	15	15	18	28	-	33
Amount of (non-piped) water collected from other sources (litres per day)								
Mean	75	356	137	367	100	500	-	6
Median	75	300	98	300	100	500	-	6
Monthly equivalent consumption of non-piped water (m^3)								
Mean	2.3	10.7	4.1	11.0	3.0	15.0	-	0.2
Median	2.3	9.0	2.9	9.0	3.0	15.0	-	0.2
One way walking time to go to the source (minutes)								
Mean	4.0	3.8	3.0	0.9	0	4.5	-	-
Median	4.0	3.5	2.0	0.5	0	4.5	-	-
Waiting time at the source (minutes)								
Mean	7.5	3.7	0.3	0.0	0.0	0.0	-	-
Median	7.5	3.5	0.0	0.0	0.0	0.0	-	-
Cost of installing the equipment to collect water from wells (SLK)								
Mean	-	2,608	-	13,414	-	-	-	-
Median	-	175[a]	-	10,000	-	-	-	-
Cost of operating the equipment to collect water from wells (SLK per month)								
Mean	-	10	-	33	-	-	-	-
Median	-	10	-	20	-	-	-	-

Notes:
(a) One household declared a total installation cost of SLK 15,000.

Table 2. Access to and use of non-piped water by non-piped households.

	Public tap	Public well	Neigh-bours	Private well	Vendors	Other surface water	Rain-water	Bottled water
Number of non-piped households…								
using water from…	98	102	313	967	11	29	8	8
Amount of non-piped water collected (litres per day)								
Mean	119	367	243	759	110	340	-	1
Median	50	400	100	500	90	343	-	1
Monthly equivalent of non-piped water consumption (cubic meters)								
Mean	3.6	11.0	7.3	22.8	3.3	10.2	-	0.0
Median	1.5	12.0	3.0	15.0	2.7	10.3	-	0.0
One way walking time to go to the source (minutes)								
Mean	5.4	5.7	3.4	0.9	-	5.1	-	-
Median	2.5	5.0	2.0	0.5	-	2.5	-	-
Waiting time at the source (minutes)								
Mean	23.8	3.8	1.0	0.0	15.0	1.9	-	-
Median	15.0	0.0	0.0	0.0	15.0	0.0	-	-
Cost of installing the equipment to collect water from wells (SLK)								
Mean	-	6,580	-	15,419	-	-	-	-
Median	-	175	-	10,000	-	-	-	-
Cost of operating the equipment to collect water from wells (SLK per month)								
Mean	-	36	-	67	-	-	-	-
Median	-	10	-	40	-	-	-	-

Table 3: Descriptive statistics on households' characteristics, water treatment, and hygiene practices.

	Non-piped households		**Piped households**		**Mean comparison test[(a)]**	
	mean	(std dev)	mean	(std dev)	Test-statistic	p-value
Household monthly wage (SLK)	13,047	(306)	15,149	(462)	-3.91	0.0001
Total monthly income (SLK)	16,725	(622)	22,259	(2,176)	-3.06	0.0022
Household size	4.68	(0.05)	4.93	(0.08)	-2.80	0.0052
Total number of rooms	3.94	(0.06)	3.98	(0.07)	-0.39	0.6959
Use of a storage tank (0/1)[(b)]	0.44	(0.01)	0.39	(0.02)	2.09	0.0365
Years of education completed by household's head	8.67	(0.09)	9.29	(0.12)	-4.03	0.0001
Household treat or filter water before drinking it (0/1)	0.40	(0.01)	0.45	(0.02)	-2.03	0.0428
Number of households	1,116		602			

Notes:
(a) For each variable, null hypothesis is equality of the mean between non-piped and piped households.
(b) Indicates a variable taking two values only: 0 or 1.

Table 4. Full sample: Estimation of the probability to have a connection to the piped network. Probit model. Maximum Likelihood estimation results

	Coef.	Std. Err.	p-value
Dependent variable: probability of having a private connection			
Constant	-0.2620	0.1683	0.1200
Income[(a)]	0.0041	0.0015	0.0060
Household size	0.0216	0.0199	0.2760
Education of the head[(b)]	0.0737	0.0120	0.0000
Access to a private well (0/1)	-1.6596	0.0757	0.0000
Access to community sources (0/1)	-0.4572	0.0751	0.0000
Concern about water[(c)] taste (0/1)	0.4184	0.1080	0.0000
Concern about water[(c)] safety (0/1)	0.0241	0.1476	0.8700
Concern about water[(c)] reliability (0/1)	0.3853	0.2130	0.0700
Kalutara district (0/1)	0.5892	0.0910	0.0000
Galle district (0/1)	0.6286	0.0835	0.0000
Number of observations	1,794		
Likelihood-ratio test	722.79	(0.0000)	
Percentage of correct predictions	79%		

Notes:
(a) Income includes estimated total monthly income of all wage earners in the household, plus any other source of income, plus any money that is remitted to the household by a family member working outside the country. Income is measured in SLK 1,000.
(b) Number of years of education completed.
(c) Water from private well.

Table 5. Estimation of water demand for piped households.

Sub-sample of piped households using piped water only OLS estimator					Sub-sample of piped households combining water from the piped network with water from other sources Seemingly Unrelated Regression Estimator			
	Coef.	Std. Err.	p-value			Coef.	Std. Err.	p-value
Dependent variable: piped water consumption, per capita per month (log)					*Dependent variable: piped water consumption, per capita per month (log)*			
Constant	1.9275	0.3978	0.0000		Constant	1.2520	0.3030	0.0000
Instrumented marginal price (log)	-0.7430	0.4446	0.0960		Instrumented marginal price (log)	-0.6940	0.1589	0.0000
Ratio of instrumented average price over instrumented marginal price (log)	-0.0176	0.0086	0.0420		Time cost (log)	0.0775	0.0342	0.0240
Income (log)	0.1014	0.0436	0.0210		Income (log)	0.1119	0.0740	0.1310
Household size	0.0072	0.0700	0.9180		Number of rooms	0.0887	0.0349	0.0110
Number of rooms	0.1156	0.0393	0.0040		Number of hours of piped water availability	0.0201	0.0071	0.0040
Household has a storage tank (0/1)	0.1995	0.0885	0.0250		Household has a yard connection only (0/1)	-0.3949	0.1273	0.0020
Household has a yard connection only (0/1)	-0.2454	0.1184	0.0390		Household has a storage tank (0/1)	0.2109	0.1146	0.0660
Number of hours of piped water availability	0.0044	0.0036	0.2260		Household has an electric pump (0/1)	-0.2902	0.1783	0.1040
Galle Four Gravets municipality (0/1)	0.1578	0.0606	0.0100		Taste concern about water from private well (0/1)	-0.0653	0.1190	0.5840
Katana municipality (0/1)	0.1797	0.1132	0.1140		Safety concern about water from private well (0/1)	0.0445	0.1638	0.7860
Negombo municipality (0/1)	0.1971	0.0680	0.0040		Mill’s ratio	-0.0933	0.1243	0.4530
Mill’s ratio	-0.0569	0.1594	0.7210					
					Number of observations	*206*		
Number of observations	*299*				*Adjusted R-squared*	*0.20*		
Adjusted R-squared	*0.27*							
					Dependent variable: non-piped water consumption, per capita per month (log)			
					Constant	0.1524	0.2875	0.5960
					Instrumented marginal price (log)	-0.3749	0.1389	0.0070
					Time cost (log)	-0.3397	0.0354	0.0000
					Income (log)	0.0020	0.0771	0.9790
					Number of hours of piped water availability	-0.0176	0.0072	0.0150
					Household has an electric pump (0/1)	0.6851	0.1732	0.0000
					Taste concern about water from private well (0/1)	0.0501	0.1241	0.6860
					Safety concern about water from private well (0/1)	-0.2192	0.1702	0.1980
					Mill’s ratio	0.2163	0.1280	0.0910
					Number of observations	*206*		
					Adjusted R-squared	*0.46*		
					Breusch-Pagan test of residuals independence: 3.210 (0.0732)			

Table 6. Estimation of water demand for non-piped households.

Whole sample of non-piped households OLS estimator					Non-piped households combining water from private well with water from neighbors Seemingly Unrelated Regression Estimator			
	Coef.	Std. Err.	p-value			Coef.	Std. Err.	p-value
Dependent variable: total non-piped water consumption per capita (log)					*Dependent variable: water collected from a private well, per capita per day (log)*			
Constant	4.2954	0.2041	0.0000		Constant	4.7657	0.3890	0.0000
Total cost (log)	0.0730	0.0183	0.0000		Time cost for collecting water from private well (log)	-0.0983	0.0260	0.0000
Time cost (log)	-0.0636	0.0105	0.0000		Time cost for collecting water from neighbors (log)	0.0706	0.0381	0.0640
Household size	-0.1441	0.0141	0.0000		Household size	-0.2174	0.0352	0.0000
Income (log)	0.0713	0.0388	0.0660		Income (log)	0.1916	0.0929	0.0390
Number of rooms	0.0832	0.0132	0.0000		Number of rooms	0.1229	0.0350	0.0000
Household has a storage tank (0/1)	0.0684	0.0586	0.2440		Household has a storage tank (0/1)	0.1792	0.2858	0.5310
Access to water provided by neighbors (0/1)	0.3080	0.0811	0.0000		Sinhalese household (0/1)	-0.3869	0.2034	0.0570
Access to a private well (0/1)	0.1028	0.1555	0.5090		Tub well (0/1)	-0.2294	0.1597	0.1510
Access to a public well (0/1)	0.2159	0.0906	0.0170		Taste concern (neighbors) (0/1)	-0.1895	0.2470	0.4430
Access to a public tap (0/1)	0.1091	0.1055	0.3010		Taste concern (private well) (0/1)	-0.1179	0.1273	0.3540
Taste concern (private well) (0/1)	-0.0274	0.0746	0.7130		Household uses an electric pump (0/1)	0.0650	0.2979	0.8270
Taste concern (public well) (0/1)	-0.0383	0.0917	0.6760		Mill's ratio	-0.1762	0.3216	0.5840
Mill's ratio	-0.0923	0.1360	0.4980					
					Number of observations	*161*		
Number of observations	*1,004*				*Adjusted R-squared*	*0.37*		
Adjusted R-squared	*0.20*							
					Constant	2.0977	0.4043	0.0000
					Time cost for collecting water from private well (log)	0.0653	0.0272	0.0160
					Time cost for collecting water from neighbors (log)	-0.3385	0.0397	0.0000
					Household size	-0.2315	0.0366	0.0000
					Income (log)	0.2247	0.0974	0.0210
					Number of rooms	0.0389	0.0362	0.2830
					Household has a storage tank (0/1)	0.0643	0.2978	0.8290
					Sinhalese household (0/1)	0.2133	0.2291	0.3520
					Taste concern (neighbors) (0/1)	-0.1763	0.2565	0.4920
					Taste concern (private well) (0/1)	0.0563	0.1353	0.6770
					Neighbour provides connection (0/1)	0.2208	0.2544	0.3850
					Neighbour provides well (0/1)	0.2461	0.1757	0.1610
					Household uses an electric pump (0/1)	-0.1774	0.3139	0.5720
					Mill's ratio	0.1258	0.3499	0.7190
					Number of observations	*161*		
					Adjusted R-squared	*0.46*		