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Households' preferences for water tariff structures in Kathmandu, Nepal

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Abstract

Despite being politically sensitive, water tariffs are frequently administered without information about households' preferences for tariff structures. In this paper we examine the tariff preferences of 1,500 households in Kathmandu, Nepal. We first use a bivariate probit model to examine stated preferences for (1) an increasing block tariff (IBT) and (2) a positive fixed charge. We find that household preferences for IBTs and fixed charges are not easily explained by household socioeconomic and water use characteristics. Second, we ask respondents what they think a fair water bill would be for a randomly assigned quantity of water. We model the responses as a function of both quantity and household socioeconomic and water use characteristics. While households support a water tariff that results in a household's water bill increasing as a household's water use increases, we do not find evidence that households support an increasing, non-linear relationship between water use and a household's water bill. Our results suggest that respondents desire affordable piped water services and water bills that are calculated fairly for everyone. Because the notion of fairness in Kathmandu varies, utility managers may have considerable latitude in choosing a tariff structure that focuses on other objectives, such as cost recovery, revenue stability, and economic efficiency.

Keywords: Household preferences; Increasing block tariff; Tariff design; Water tariff structure

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Introduction

Water utility managers, their tariff consultants, and regulators rarely consult a utility's customers about the form of tariff structure households would prefer. Both citizens and water utility managers pay a great deal of attention to changes in fixed charges and volumetric prices charged to customers, but much less attention to customers' preferences for the tariff structure itself. Water tariff design is typically assumed to be best left to experts who can most appropriately balance the utility's objectives of cost recovery and revenue stability with their customers' objectives of equity, fairness, affordability, and economic efficiency.

Because in most locations water utilities operate as monopoly suppliers of piped water and sewer services, their tariff structures are effectively administered prices, and utility customers have few opportunities to reveal their preferences for alternative pricing structures[1]. As a result, there can be a serious mismatch between the water tariff structure used and household preferences for the tariff structure. Unpopular tariff structures can have a long life because customers have no easy way to drive them out of the market. This is quite different, for example, from the telecommunications sector where competition can be intense. Mobile phone companies are consistently offering customers a variety of different rate plans from which they can choose, and unpopular rate plans quickly disappear from the market.

There is a sizeable consulting business in the preparation of tariff studies for water utilities, and there is near global consensus among water utility managers and international donors that increasing block tariffs (IBTs) are the tariff structure best suited to balancing the multiple objectives of tariff design, and ensuring that poor households have access to sufficient quantities of water at affordable prices. Consultants specializing in advising water utilities on water tariff structures and price levels typically assume that an IBT should be used, and then discuss with utility management the pros and cons of such issues as the number and size of blocks, the size of any positive fixed charges, minimum monthly water bills, and seasonal pricing.

Numerous scholars, however, have challenged this global consensus on IBTs, arguing that IBTs neither target subsidies to poor households effectively nor send the correct signals about the economic value of water (Boland & Whittington, 2000; Foster & Araujo, 2004; Komives *et al*., 2007; Diakité *et al*., 2009; Angel-Urdinola & Wodon, 2012; Whittington *et al*., 2015; Fuente *et al*., 2016; Nauges & Whittington, 2017). Given this debate between scholars and practitioners over the efficiency and effectiveness of IBTs, it is timely to ask what households themselves think. In fact, utilities rarely elicit input from households on tariff design issues. In some countries, public hearings might be held to gauge citizens' reactions to specific proposals from tariff consultants, but such input is often sought after the main tariff design issues have already been decided.

There are several reasons that household preferences should be considered in the selection of a water tariff structure. First, households may have a preference for a specific water tariff structure, and the utility's choice of tariff structure may affect their well-being. From a cost–benefit perspective, ignoring household preferences will miss an opportunity to increase welfare. Second, households are probably more likely to pay water bills and to support a water utility that uses a tariff structure that they believe is fair and efficient. Perceptions of fairness are important for the cooperation of households with an institution (Pokharel, 2015). Third, many households likely believe that they have a right to have their voices heard in matters

[1] In Scotland, some households are now able to choose their bulk water supplier, but globally this is very rare.

of pricing such basic services as water. Ignoring household preferences on the tariff structure deployed may expose water utilities and policy-makers to greater political risks (Crase *et al*., 2008).

Water tariff structures are often designed based on certain assumptions about household behaviors and how such behaviors may be altered by price mechanisms. Such assumptions should be based on a careful investigation of households' preferences. For example, IBTs are often proposed based on the assumption that they will provide the right 'price signal' to consumers. In fact, this marginal price signal can only be provided to households in one of the blocks of the IBT (most likely the highest price block).

In this paper we report the results from a survey conducted in 2014 of 1,500 households in Kathmandu, Nepal, in which we asked respondents for their opinions about different water tariff structures. Specifically, we asked households about their preferences regarding three attributes of a water tariff: (1) its structure (IBT vs uniform volumetric pricing); (2) positive fixed charges; and (3) household flexibility in selecting rate plans. We collected information on households' knowledge, attitudes, and perceptions about the water services in Kathmandu; and households' urban environmental and infrastructure priorities. We also asked respondents what they thought a 'fair water bill' would be for a randomly assigned fixed quantity of water. We analyzed these answers to determine whether respondents had a preference for increasing nonlinear tariff structures. We find that respondents support monthly water bills that increase linearly as the quantity of water use increases.

In the next section of the paper, we summarize the prevalence of different tariff structures being used globally and then present the tariff structure currently used in Kathmandu. The third section describes our fieldwork in Kathmandu and provides a socioeconomic profile of our sample respondents. The fourth section describes our analytical strategy. In the fifth section we present the results. We first describe households' knowledge, attitudes, and perceptions about the water supply in Kathmandu, and the priority they place on reducing water shortages compared to other urban problems. We then present our results regarding households' preferences for different attributes of water tariff structures, as well as regression analyses that examine the types of households that prefer different tariff structures. The sixth section summarizes our results and offers concluding remarks.

Background

Most water utilities globally now use IBTs to calculate customers' water bills. The Global Water Intelligence (GWI) database reported 122 out of 165 selected utilities from around the world were using IBTs in 2013. China had been one of the last refuges of uniform volumetric tariffs, but in 2013, the Chinese government mandated that all cities in China must adopt IBTs by the end of 2015 (National Development and Reform Commission, 2013). The predominance of IBTs globally can be expected to grow as Chinese cities make the shift to IBTs over the next few years.

Although there is a clear preference for the basic IBT structure, there is no consensus on the details. IBTs have four main features: (1) number of blocks; (2) size of the blocks, especially the first ('lifeline') block; (3) presence and size of a positive fixed charge; and (4) the volumetric prices charged in each block. Tariff consultants and utility managers argue over these features, and there is wide variation across all four globally.

For example, the number of blocks in the IBTs in the GWI database varies widely. Of the 122 IBTs, the most common number of blocks was three (28%), followed by four blocks (21%). However, 6% had two blocks, 11% had five blocks, 10% had six blocks, 7% had seven blocks, and 18% had eight blocks.

The GWI database also reports sizes of the first (lifeline) block for the IBTs. The median size is 10 m^3 in East Asia, South Asia, and Latin America, and somewhat lower in North and sub-Saharan Africa (8 and 7 m^3 per month, respectively), but the standard deviation is large. With such large lifeline blocks, it is not usual for some utilities to have a large proportion, even a majority, of their residential consumers falling into the lifeline block.

Positive fixed charges raise the average price paid by small volume-using households more than that of large volume-using households and thus penalize the same households that the IBT's lifeline block is designed to help. Nevertheless, most water utilities in the GWI database that use IBTs (70%) add a positive fixed charge to the volumetric component of their customers' water bills. The mean positive fixed charge was US$4.35 per month. Only 30% of utilities with uniform volumetric tariffs add a fixed charge, and their average fixed charge is lower (US$3.20 per month)[2], which suggests that more of these uniform tariff-setting utilities may be aware of the adverse effect of fixed charges on poor households.

One would expect volumetric prices in different blocks to vary across utilities due to differences in the costs of water and wastewater services, and the differences are indeed substantial. However, across all of the IBT structures, volumetric prices are very low in all of the blocks (not just the lifeline block). Considering only the 34 IBTs with three blocks (the most common IBT in the GWI database), the median volumetric price was US$0.35 per cubic meter in the first block, US$0.57 per cubic meter in the second block, and US$0.75 per cubic meter in the third block.

Most water utilities subsidize water use, and the average cost of water supply is more than the price in the highest-price block. Thus, the more water a household uses, the higher the subsidy it receives (Nauges & Whittington, 2017).

Kathmandu case study

The Kathmandu water utility (Kathmandu Upatyaka Khanepani Limited, KUKL) uses an IBT with a minimum bill. KUKL currently has about 190,000 residential customers (KUKL, 2015). The water bills of households with both metered and unmetered connections to the pipe network are calculated based on the pipe size of their connection. Most connected households have a half-inch pipe connection. Households with a metered one-half inch pipe connection are charged 100 NPR (US$0.96) for the first 10 cubic meters. For additional water use above the minimum 10 cubic meters, a household is charged 32 NPR (US$0.31) per cubic meter. For example, a household with a metered half-inch pipe connection that used 18 cubic meters a month would receive a water bill of 356 NPR (100 NPR for the first 10 cubic meters plus 32 NPR per cubic meter for the subsequent 8 cubic meters). Households with half-inch, unmetered connections are charged 785 NPR (US$7.50) per month.

This tariff structure has the appearance of an IBT because, if the household uses all 10 cubic meters, its average price is just 10 NPR (≈US$0.10) per cubic meter, and for additional water use the price is 32 NPR per cubic meter. However, the minimum bill of 100 NPR means that the marginal price for additional water use within the 'lifeline' block of 10 cubic meters is effectively zero because households

[2] The median positive fixed charges in East Asia (US$5) and Latin America (US$4 per month) are much higher than those in sub-Saharan Africa, the Middle East, North Africa, and South Asia (all about US$1 per month).

must pay this minimum charge regardless of how much water they use (e.g., they are charged the same 100 NPR whether they use 5, 7, or 10 cubic meters).

The implementation of an infrastructure investment program (the Melamchi Water Supply Project) is now underway. When completed, it will provide a new raw water supply for the Kathmandu Valley, and improvements in both the water and wastewater networks, as well as wastewater treatment facilities. Donor support for this project had been conditional upon tariff reform, and originally consultants had estimated that a 13-fold increase of the water tariff would be required between 1999 and 2009 to meet operating costs of the water network (Domènech *et al*., 2013). The revised 2009 tariff increased the tariff set in 2004 by 10–30%, depending on the amount consumed (Himalayan Times, 2009; ADB, 2013). It included a lifeline block, but NGOs deemed this insufficient to assist poor households and demanded targeted subsidies for the poor (Gutierrez *et al*., 2003; Domènech *et al*., 2013). A new tariff structure was introduced in 2013, which increased the average tariff by 82%. This price increase, however, was still not enough to cover operating and maintenance costs, service charges, and debt (ADB, 2015). Further changes in the current tariff structure are thus a possibility, and our questions about tariff preferences were highly salient to sample respondents.

Fieldwork and socioeconomic profile of sample respondents

Our survey of 1,500 households was conducted in five municipalities in the Kathmandu Valley (Kathmandu, Lalitpur, Bhaktapur, Kirtipur, and Madhyapur) from August to October 2014. Households in this 2014 survey were selected based on a 2001 sample that was drawn to be representative of the population of Kathmandu at the time (Gurung *et al*., 2017). We chose to re-interview the households from 2001 in order to construct a panel dataset. The sample is thus not representative of the 2014 population of households (differences are reported in the Appendix, Table A1, available online). In 2001, households were selected using a multi-stage clustered sampling procedure (see Whittington *et al*. (2002) and Pattanayak *et al*. (2005) for more details). In the 2014 re-survey of the 2001 households, if we were unable to locate the original household, a nearby household in the same cluster was selected for an interview[3]. In total, we were able to locate and re-interview 927 of the 1,500 households in the 2001 survey. In the 2014 survey, there are thus 573 replacement households[4].

Table 1 presents a socioeconomic profile of the sample households. As shown, monthly mean household income was 70,441 NPR (about US$700). The average household size was five members. The average age of the head of household was 57 years (reflecting the sampling strategy of re-surveying the 2001 sample). Table 1 also reports summary statistics on infrastructure services and housing. Virtually every household in the sample had electricity (99.7%) and some sort of access to the telecommunications network (98%), either via a landline (64%) or a cellphone. Households had, on average,

[3] If the household head from the 2001 sample household was missing, the next most senior member of the house was interviewed.

[4] Although the 2001 households were a representative sample of the population in the five municipalities in Kathmandu Valley, the sample from the 2014 re-survey is not because many households migrated to Kathmandu over the period from 2001 to 2014. These households are not part of our 2014 sample unless they happened to be included as a replacement household. Appendix Table A1 shows that the survey households are more likely to be homeowners, to use LP gas as the cooking fuel, to have a flush toilet connected to the sewer systems, to own more durable goods, and are more likely to be literate in Kathmandu and Lalitpur.

Table 1. Socioeconomic profile of sample households.

Variable	N	Median	Mean	SD
Monthly household income	1,500	57,500	70,441	74,299
Household size	1,500	5	5.05	2.12
Head of household age	1,500	56	56.52	12.86
Electricity	1,500	1	1.00	0.05
Landline	1,500	1	0.64	0.48
Number of cellphones	1,495	3	3.20	1.64
Electricity bill	1,476	700	897	749
Phone bill	1,500	1,000	1,288	1,178

three cellphones. Mean monthly phone bills were 1,288 NPR (US$13), about 2% of monthly income. Average monthly electricity bills were 897 NPR (US$9), about 1% of monthly income.

Table 2 presents some quantitative characteristics of the piped water system, as reported by our respondents. Seventy per cent of the sample households had a private water connection. Households with private connections reported that they received very little water from their connection during the dry season (median and mean are 75 and 126 L/household/day, respectively), and about twice that during the rainy season (median and mean of 143 and 240 L/household/day, respectively). Households received water from their private connections for only about an hour to an hour and a half, on average, once every 5 days. Most households (59%) reported having a working water meter, and 67% received a water bill (a large majority reporting receiving their bill monthly). The median monthly bill of a household was 150 NPR (US$1.55), with a mean water bill of 218 NPR (US$2.25), 0.5% of monthly household income. The average price paid for the water from a private connection was 170 NPR per m^3 (US$1.75 per m^3); the median price was 71 NPR per m^3 (US$0.73 per m^3).

Analytical strategy for investigating households' preferences for water tariff structures

We examine households' preferences for different tariff structures in two ways. First, we asked respondents a series of direct questions. Enumerators explained to each of the households in the

Table 2. Piped water summary statistics.

	N	Median	Mean	SD
Private water connection (1 = yes, 0 = no)	1,500	1	0.70	0.46
Water use – rainy season (L/day)	1,046	143	240	329
Water use – dry season (L/day)	988	75	126	183
Days between service	1,051	5	4.99	2.93
Length of service each time water comes (min)	1,050	60	98.6	84.2
Hours of service per month	1,050	7.5	11.5	14.2
Water meter (1 = yes, 0 = no)	1,500	1	0.63	0.48
Working water meter (1 = yes, 0 = no)	1,500	1	0.59	0.49
Received water bill (1 = yes, 0 = no)	1,500	1	0.67	0.47
Monthly water bill	1,051	150	218	229
Average price paid for water from the piped connection (NPR/m^3)	988	71	170	337

2014 survey how water bills are calculated when a water utility uses either a uniform volumetric tariff or an IBT. Respondents were not given specific volumetric prices for the two tariff structures, or other details about the IBT structure, such as the number and size of blocks.

Respondents were then asked which tariff structure they would prefer the water utility to adopt and the reasons why they selected their preferred tariff structure. Enumerators next asked respondents whether their choice of tariff structure was based on whether it was best for their household or all the households in Kathmandu.

Enumerators also explained that many water utilities used a two-part tariff that added a positive fixed charge to the volumetric component to calculate customers' water bills. Respondents were asked if they thought the use of a positive fixed charge was a good idea. Next, enumerators reminded respondents that mobile phone customers could choose the rate plan (tariff structure) that best suited their household. Enumerators asked respondents if they would like to be able to choose their tariff structure for piped water and wastewater services (even if the respondent's household did not have a piped connection).

We checked respondents' understanding of the IBT concept. Those who did not pass the check question (e.g., 'IBT means that the price per unit of water will increase in stages as a household's total water use increases. True or False?') are not included in all parts of the analysis ($N = 271$ from 1,500 households). Understanding of the IBT concept is most critical for the choice between an IBT and uniform volumetric tariff structure; it is not as important for respondents' choice of a fixed charge[5].

The propensity to select an IBT and the propensity to select a fixed charge are both dichotomous variables. Therefore, a latent variable model is used to examine their relationships with each other and socioeconomic factors, water use, and other preferences. Because these decision variables could be connected, unobservable variables may affect both the propensity to choose an IBT and a fixed charge. The seemingly unrelated probit model jointly estimates these two propensities with their correlated disturbances (Greene, 2011). We test for exogeneity using maximum-likelihood simultaneous estimation of the two probit equations, i.e., recursive bivariate probit (Maddala, 1983; Costa-Font & Gil, 2005). This model allows us to correct for some of the unobserved heterogeneity that can contribute to omitted variable bias and is also expected to increase the efficiency of the estimation (Costa-Font & Gil, 2005; Greene, 2011).

The specification for our two-equation model is as follows:

$$IBT_i^* = \beta_0 + \beta_1 SE_{1i} + \varepsilon_{1i},\ IBT_i = 1 \text{ if } IBT_i^* > 0,\ 0 \text{ otherwise,} \tag{1}$$

$$Fixed_i^* = \delta_0 + \delta_1 SE_{2i} + \varepsilon_{2i},\ Fixed_i = 1 \text{ if } Fixed_i^* > 0,\ 0 \text{ otherwise, } \begin{pmatrix} \varepsilon_{1i} \\ \varepsilon_{2i} \end{pmatrix} | SE_{1i},\ SE_{2i} \sim N\left[\begin{pmatrix} 0 \\ 0 \end{pmatrix}, \begin{pmatrix} 1 & \rho \\ \rho & 1 \end{pmatrix}\right] \tag{2}$$

where IBT_i = binary indicator for household i's stated preference for a uniform volumetric or IBT, $Fixed_i$ = binary indicator for household i's stated preference for a fixed charge, SE_{1i}, SE_{2i} = vector of socioeconomic characteristics of household i, ε_{1i}, ε_{2i} = random error terms.

[5] Appendix Table A2 shows the differences between these two sub-samples. Respondents who responded 'not sure' or 'do not know' are also excluded (N = 22). A selection model was considered but the likelihood ratio test of independent equations failed to be rejected, suggesting there is no selection bias due to a respondent initially failing to pass the check question.

IBT_i^*, $Fixed_i^*$ are latent variables observed as dummy variables IBT_i, $Fixed_i$, respectively. SE_{1i}, SE_{2i} are exogenous variables, and β_0, β_1, δ_0, δ_1 are parameters of the preference functions. The error terms of the two equations are modeled to be dependent and distributed as a bivariate normal. The Wald test for $\rho = 0$ provides evidence about the correlation between the error terms of the equations and if the models should therefore be jointly estimated.

Second, in a different section of the questionnaire, households were also asked the following question:

After the Melamchi water supply project is completed, households with piped water connections will have better service. What do you think a fair[6] *monthly water bill would be for a household that uses [5000, 10000, 15,000, 20,000, 25,000, 30,000] liters per month?*

The different quantities of monthly water use (5,000, 10,000, 15,000, 20,000, 25,000, 30,000 liters per month; or 5, 10, 15, 20, 25, 30 m^3 per month) were randomly assigned to sample respondents. Each respondent answered this question only once for the single randomly assigned quantity that they received. We estimated the relationship between the respondent's reported 'fair monthly water bill,' the exogenously assigned quantity and socioeconomic covariates of the respondent's household socioeconomic characteristics using the following equation:

$$\mathrm{WaterBill_i} = \beta_0 + \beta_1 \mathrm{Q_i} + \beta_2 (\mathrm{Q_{ij}})^2 + \beta_3 \mathrm{SE_i} + \varepsilon \tag{3}$$

where $\mathrm{WaterBill_i}$ = self-reported fair water bill of household i, $\mathrm{Q_{i,j}}$ = quantity of water j randomly assigned to household i (j = 5,000, 10,000, 15,000, 20,000, 25,000, 30,000 liters per month), $\mathrm{SE_i}$ = vector of socioeconomic characteristics of household i.

We expect that respondents, in aggregate, believe it would be fair for a household that uses more water to pay a higher water bill, so $\beta_1 > 0$. We are agnostic about the sign and significance of β_2. If respondents, in aggregate, believe that a household that uses more water should pay an increasingly higher water bill, then $\beta_2 > 0$. For example, if households favor an IBT or other form of increasing nonlinear tariff structure, then we expect $\beta_2 > 0$. Similarly, if households favor a decreasing block or other decreasing nonlinear tariff structure, $\beta_2 < 0$. If households favor a uniform volumetric tariff, we expect β_1 to be positive, but for β_2 not to be statistically significant.

This model describes aggregated household preferences. Households were not asked to state fair monthly water bills for multiple hypothetical quantities, so we cannot use these data to test whether the respondent understood how the household's water bill would be calculated if an IBT were used. Even if all households preferred and understood an IBT, they may still disagree on sizes and prices of blocks, and thus β_1 and β_s might not necessarily be significant and/or positive.

For all three models, fixed effects at the municipality level are included. Standard errors are clustered at the neighborhood level.

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[6] We note that there is no direct translation for the word 'fair' in Nepali. There are two closely related words in Nepali that reflect two closely related concepts – fairness in process and fairness in outcome (Pokharel, 2015). However, these concepts do not apply precisely to the task of expressing a single estimate for a 'fair' water bill associated with a specified quantity of water. However, we believe that respondents' answers to the question posed reflect an understanding of the English meaning of 'fair water bill'.

Results

Salience of the water supply situation in Kathmandu

We first demonstrate that the water shortage in Kathmandu was highly salient to sample respondents. Table 3 reports respondents' answers to a question that asked their first, second, and third priorities from a predetermined list of environmental and infrastructure problems. Respondents were most concerned about three urban infrastructure problems: (1) water shortage, (2) electricity outages, and (3) poor garbage collection and solid waste management. Of these three, addressing the water shortage was overwhelmingly respondents' top priority.

This conclusion is reinforced by respondents' answers to another question in the survey. We told respondents in households with and without private connections to:

> *'… Suppose that you are able to have potable water from a private connection and the water service is available several hours per day, seven days per week, and that your monthly water bill will be equal to or less than what you are currently paying for water from all sources. In which of the following areas would you like to adjust your water use: drinking, cooking, bathing, cleaning house, outdoor gardening?'*

The closed-end answers were, 'increased a little,' 'increased substantially' and 'no change.' Table 4 shows that the majority of respondents expect that their household's water use would increase a little or substantially for three large components of household water uses: bathing, cleaning house, and outdoor gardening.

Preferences for IBT vs uniform volumetric, fixed charges, tariff flexibility at the household level

We next examine reported preferences for tariff structures, fixed charges, and tariff flexibility at the household level. We also examine water infrastructure and socioeconomic characteristics of households

Table 3. Urban environmental and infrastructure priorities*.

	First	Second	Third
Water shortage	57%	21%	9%
Electricity outage	14%	39%	23%
Air pollution	9%	5%	10%
Poor garbage collection and solid waste	8%	15%	27%
Contamination of drinking water	6%	7%	9%
Poor sewerage	5%	8%	9%
Improper disposal of hazardous wastes	1%	1%	2%
Water pollution in rivers	1%	2%	5%
Poor drainage/flooding	0%	2%	2%
Too much noise	0%	1%	2%

*Survey question: Which one of these environmental problems is the (first/second/third) most important that the government should solve in this city?

Table 4. Anticipated changes in water use after completion of Melamchi Project (number of respondents).

	Increase a little	Increase substantially	No change
1. Drinking	234	31	1,235
2. Cooking	409	55	1,036
3. Bathing	808	309	383
4. Cleaning house	820	318	362
5. Outdoor gardening	765	290	445
6. Washing clothes	53	32	1,415

that are associated with their tariff preferences. We first report the descriptive statistics and then the results of our probit models.

Table 5 compares the characteristics of households who prefer the IBT to a uniform volumetric rate. Fifty-eight percent of households (705 households) expressed a preference for the IBT compared to the uniform volumetric tariff (505 households). Twenty-five per cent of those who preferred the IBT also preferred a positive fixed charge. Most of those who prefer a uniform volumetric tariff (59%) also prefer a positive fixed charge. Additionally, 70% of all households preferred to have some choice of their water tariff structure.

Most respondents (78%) said that their choice of tariff structure was based on what they thought would be best for everyone in Kathmandu, not just themselves; 22% said that they were thinking

Table 5. Household tariff preferences.

	Preferred IBT	Preferred uniform volumetric tariff	Total
Tariff choice (number of households)	705	505	1,210
Preferred positive fixed charge	25%	59%	39%
Tariff flexibility	70%	70%	70%
Considered other households in Kathmandu in tariff choice	84%	70%	78%
Current water use from tap (m^3/month)	1.67	2.82	2.15
Reasons for tariff choice	My household gets a discount if we use less water (42%)	Same price rate for all customers (42%)	
	People who consume more water should pay higher prices for the extra water they consume (30%)	Encourages water conservation (21%)	
	Encourages water conservation (18%)	Cost of supplying water is the same so price should be the same (20%)	
	Helps poor households (10%)	Easy to calculate expenses on piped water (13%)	
What do you like least about the service from the piped water connection?	Less than 24-hour service (39%)	Less than 24-hour service (59%)	
	Unfair distribution (31%)	Poor water quality (19%)	
	Poor water quality (21%)	Unfair distribution (16%)	

about their own household. Those who preferred the IBT were more likely to report that they based their decision on what was good for everyone in Kathmandu (84%) compared to those who preferred the uniform tariff (70% said they based their decision on what was good for everyone in Kathmandu).

We then asked the reasons for preferring one tariff structure over the other. Those who chose the IBT said that they like the fact that they could 'get [a] discount if [they] use less water' (42%), suggesting that the price of water in the higher-priced blocks may have been perceived as the default price. They also believe that 'people who consume more water should pay [a] higher price for the extra water they consume' (30%). Those who chose the uniform tariff said that they liked the fact that it is the 'same price for all customers' (42%), that it '[encourages] water conservation' (21%), and that because 'the cost of supplying water is the same, the price should also be the same' (20%).

For those who answered that they were thinking mostly about their own family, we asked if their tariff structure preference would change if they thought about all households instead of just about themselves. Twenty-three per cent of those who initially chose the IBT stated they would change their answer. Similarly, 21% of those who initially chose the uniform tariff also said that they would change their answer. In contrast, only about 2% of those who said they based their decision on what was good for everyone in Kathmandu stated they would change their answer if they were thinking only about their own family.

Finally, we asked respondents if those with a connection to the piped water network should be able to choose the tariff plan that they want, just as cell phone users are. A majority of respondents (68%) responded yes, households should be able to choose, while 18% said households should not be allowed to, and 14% of respondents were unsure.

Table 6 presents the summary statistics for the dependent variables used in Equations (1)–(3), the key socioeconomic characteristics of the household (income, household size, respondent's education, head of the household responding), variables related to water usage (monthly expenditures, quantity of water collected from the tap), water shortage being the most important environmental problem, and other independent variables of interest. The literature on determinants of household preferences for IBTs is limited and provides little guidance on appropriate model specifications and covariates. Crase *et al.* (2007) find that households that supported an IBT are more likely to report a larger number of activities that use water. They also include socioeconomic variables as co-variates but find no significant association between household support for an IBT and age, household size, household income, or the size of the last water bill.

Table 7 shows the relationship between the stated preferences for an IBT and a fixed charge. Forty-two per cent of the sample ($N = 1,167$) prefer an IBT but not a fixed charge; 25% prefer a fixed charge and a uniform tariff instead of an IBT. Seventeen per cent do not want a fixed charge and do not prefer an IBT; 15% prefer both a fixed charge and an IBT. The tetrachoric correlation coefficient is estimated at -0.509, with an asymptotic standard error of 0.038, showing that those who prefer an IBT are less likely to prefer a fixed charge.

Table 8 reports the results of the bivariate probit model of preferences for IBTs and fixed charges. The first specification for both models looks only at socioeconomic controls: income, household size, respondent education, and if the respondent is the head of the household. Models (1) and (2) are estimated simultaneously. Model (1) shows that for household preferences for IBTs, income and household size do not have significant coefficients. More educated respondents are more likely to choose an IBT, and respondents that are household heads are less likely to choose an IBT. There are also municipality effects; households living in Kirtipur and Madyapur Thimi are more likely to choose an IBT compared to households living in Kathmandu (municipality). Model (2) shows that for household preferences for fixed charges, household income, and head of household have statistically significant

Table 6. Summary statistics.

Variable	Variable description	N	Mean	SD	Min	Max
ibt	Increasing block is best for KUKL to adopt (1 = yes, 0 = no)	1,210	0.58	0.49	0	1
fixed	Favors fixed charge in water bill (1 = yes, 0 = no)	1,439	0.40	0.49	0	1
fair_bill	Fair water bill post-Melamchi (NPR/month)	1,283	528	637	100	10,000
hyp_usage	Exogenously assigned hypothetical household usage (L)	1,500	16,150	8,118	5,000	30,000
hyp_usage_sq	Hypothetical household usage squared	1,500	3.3×10^8	2.8×10^8	2.5×10^7	9.0×10^8
ln_income	ln(Total household reported income)	1,450	10.92	0.76	6.21	13.92
nhh	Household size	1,500	5.05	2.12	1	15
resp_edu	Highest level of education of respondent (years), with illiteracy coded as zero	1,500	8.38	6.22	0	18
resp_illiterate	Respondent is illiterate (1 = yes, 0 = no)	1,500	0.219	0.413	0	1
resp_hhhead	Respondent is household head (1 = yes, 0 = no)	1,500	0.529	0.499	0	1
ln_monthlywaterexp	ln(Perceived monthly expenditures on water (NPR))	1,500	725	921	0	9,130
pwc_m3	Estimated quantity of water collected from piped water connection (m^3/month, dry season)	1,500	2.49	4.81	0	90
priority_water	Water shortage is first most important environmental problem (1 = yes, 0 = no)	1,500	0.57	0.50	0	1
consider_ktm	When choosing preferred tariff, thinking about what is best for everyone in Kathmandu (1 = yes, 0 = no)	1,500	0.76	0.42	0	1
change_mind	Answer would change if thinking about other group (either own hh or everyone) (1 = yes, 0 = no)	1,500	0.07	0.25	0	1

Table 7. Stated preferences for IBTs and fixed charges.

	No fixed charge	Fixed charge	Total
Uniform	201	297	498
IBT	494	175	669
Total	695	472	1,167

coefficients at the 1% and 10% levels, respectively. The higher the household income, the less likely the household is to prefer a fixed charge. Heads of households are more likely to prefer a fixed charge. Household preferences for fixed charges do not have a statistically significant relationship with household size, respondent education, or municipality.

The second set of specifications in Table 8 adds covariates related to water usage: monthly water expenditures (*ln_monthlywaterexp*), quantity of water collected from the private tap (*pwc_m3*), and if water shortage is the most important environmental problem (*priority_water*). Models (3) and (4) are estimated simultaneously. In model (3), the coefficient on quantity of water collected from the private tap (*pwc_m3*) is significant at the 1% level and is negative. The more water the respondent's household obtains from the private water connection, the less likely they were to choose an IBT. The addition of these water usage variables does not change the sign or significance of other variables, except for size of household (*nhh*), which becomes significant at the 10% level. In model (4), the coefficients on the water usage variables are not statistically significant.

Table 8. Biprobit regressions of preferences for IBTs and fixed charges.

Variables	(1) ibt	(2) fixed	(3) ibt	(4) fixed	(5) ibt	(6) fixed
ln_income	0.0710 (0.0582)	−0.158*** (0.0583)	0.0800 (0.0589)	−0.156** (0.0620)	0.0859 (0.0575)	−0.156*** (0.0604)
nhh	−0.0327 (0.0213)	0.0139 (0.0176)	−0.0365* (0.0210)	0.0155 (0.0174)	−0.0395* (0.0224)	0.0178 (0.0174)
resp_edu	0.0227*** (0.00723)	0.00384 (0.00966)	0.0237*** (0.00693)	0.00371 (0.0100)	0.0221*** (0.00719)	0.00407 (0.0100)
resp_illiterate	0.252** (0.119)	−0.00805 (0.127)	0.263** (0.115)	−0.0148 (0.126)	0.234* (0.121)	−0.00697 (0.126)
resp_hhhead	−0.175** (0.0744)	0.159* (0.0861)	−0.189** (0.0776)	0.166** (0.0845)	−0.204** (0.0797)	0.176** (0.0860)
ln_monthlywaterexp			0.0394 (0.0340)	−0.0329 (0.0228)	0.0480 (0.0331)	−0.0360 (0.0224)
pwc_m3			−0.0445*** (0.0136)	0.00811 (0.0108)	−0.0498*** (0.0134)	0.00984 (0.0113)
priority_water			−0.0693 (0.102)	−0.0901 (0.110)	−0.0378 (0.0983)	−0.105 (0.109)
consider_ktm					0.590*** (0.142)	−0.243 (0.175)
change_mind					0.203 (0.160)	0.136 (0.207)
Municipality – Lalitpur	0.270* (0.158)	−0.0353 (0.150)	0.254 (0.165)	−0.0490 (0.146)	0.205 (0.160)	−0.0173 (0.155)
Municipality – Bhaktapur	0.210 (0.160)	0.183 (0.136)	0.318 (0.225)	0.105 (0.141)	0.277 (0.243)	0.101 (0.137)
Municipality – Kirtipur	0.768*** (0.137)	−0.139 (0.165)	0.895*** (0.195)	−0.251 (0.167)	0.886*** (0.199)	−0.222 (0.171)
Municipality – Madhyapur Thimi	0.629*** (0.205)	0.0934 (0.162)	0.613*** (0.211)	0.111 (0.176)	0.588*** (0.217)	0.147 (0.180)
Constant	−0.724 (0.640)	1.292** (0.600)	−0.895 (0.665)	1.480** (0.648)	−1.423** (0.631)	1.654*** (0.641)
Observations	1,135		1,135		1,135	
Rho	− 0.518***		− 0.514***		− 0.506***	
Wald test of rho = 0 (*p*-value)	0.000		0.000		0.000	
AIC	2,916		2,905		2,873	
Wald Chi-square	170.1		225.7		403.8	
Correct classification (%)	43.6%		45.2%		45.3%	

Robust standard errors in parentheses.
$^{***}p < 0.01$, $^{**}p < 0.05$, $^{*}p < 0.1$.

The third set of specifications includes two additional variables: (1) whether the respondent was thinking about her own household or all of Kathmandu (*consider_ktm*) and (2) if they would change their mind (*change_mind*) when considering the other group instead (either own household or all of Kathmandu). Models (5) and (6) are estimated simultaneously. In model (5), the coefficient on whether the respondent considers all of Kathmandu when selecting the preferred tariff structure (*consider_ktm*) is positive and significant at the 1% level. When the respondent considers the larger community, they are more likely to select an IBT over a uniform volumetric tariff. In model (6), we find that neither considering all of Kathmandu nor changing their mind have statistically significant effects on household preferences for a fixed charge.

Across all specifications, the value of the correlation between the error terms of the IBT and fixed charge equations (*rho*) and its significance level are reported. All specifications show *rho* values that are significant at the 1% level, rejecting the null hypothesis that $rho = 0$ and that the error terms are uncorrelated. Comparing the specifications, we look at the Akaike information criteria (AIC). The last specification reports the lowest AIC of 2,873 and is therefore the preferred specification. The Wald Chi-square test statistics are sufficiently high for all models to reject the null hypothesis that all coefficients in the model are zero. However, the ability for the three specifications to correctly classify both outcomes is low, ranging from 43.6% to 45.3%.

The models describing household preferences for IBTs and fixed charges are relatively weak, with low predictive abilities. However, we do find that households that are more likely to be large users (larger household and higher monthly water consumption) are less likely to favor IBTs. This is not surprising if households are rational economic actors and are cost-minimizing. Additionally, considering what is good for Kathmandu as a whole has a large and significant coefficient, suggesting that households' intuition and opinions agree with common pro-IBT arguments (Boland & Whittington, 2000). Paired with the qualitative questions about reasons for preferring one tariff structure over another, these findings make sense. It would seem that ideas about fairness or social justice (i.e., 'good for everyone in Kathmandu'), cost-minimization, and water conservation drive household preferences, and are not easily approximated using household socioeconomic and water use characteristics.

Preferences for nonlinear tariff structures: fair water bills

Figure 1 presents the frequency distributions of respondents' reported fair water bills at each of the exogenously assigned monthly quantities of water use. These frequency distributions show that reported fair water bills gradually shift higher as the quantity of water increases, but many respondents reported very low 'fair water bills' at all quantities. There was also a great deal of heterogeneity in reported fair water bills at each exogenously assigned monthly quantity of water use.

Table 9 describes respondents' reported fair water bills and implicit average water prices at different hypothetical monthly quantities of water, with references to what the water bill and average water price would be under the current KUKL water tariff structure. For the overall sample, the fair water bill is monotonically increasing as a function of hypothetical water use. The mean fair water bill is higher than what the household would pay under the current tariff for all hypothetical water use levels. The correlation coefficient between fair water bill and the hypothetical monthly water quantity is positive but low (Pearson's is 0.27 and Spearman's is 0.38). Many respondents report a very low 'fair water bill' at all quantities. The implicit average water price is monotonically decreasing in volume of water use (except for the mean

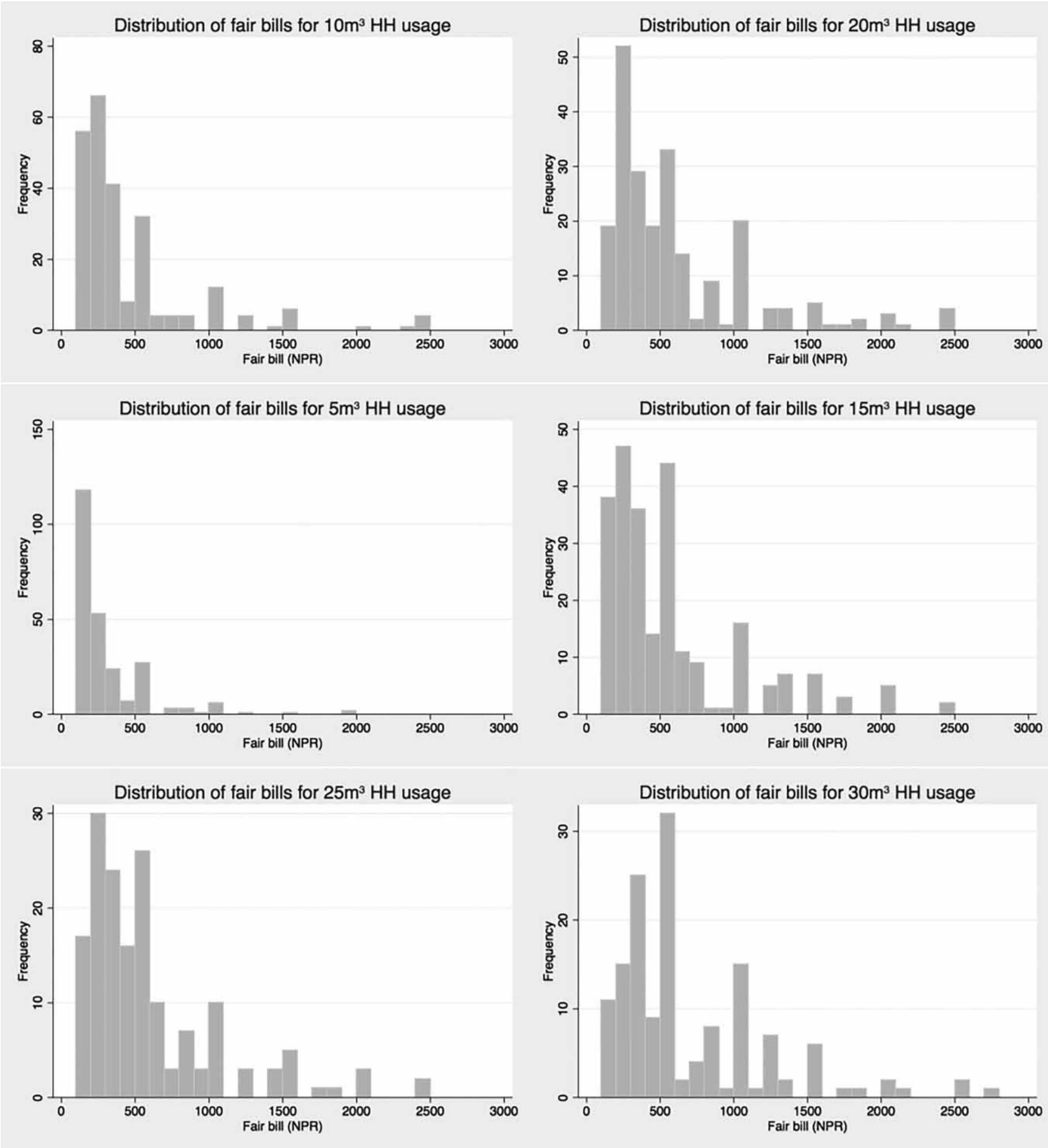

Fig. 1. Distribution of responses for fair monthly water bill by exogenously assigned hypothetical household usage.

price at 30 m^3/month). Again, the mean implicit average water price is also much higher than what the household would pay under the current tariff – more than double for 5, 10, and 15 m^3.

Comparing the frequency distributions of reported fair water bills for those who preferred an IBT with those who prefer a uniform volumetric tariff, we see lower fair water bills and implicit average water

Table 9. Fair water bill by hypothetical use.

			Fair water bill (NPR/month)			Implicit average water price (USD/m^3)			
Hypothetical water use (m^3/month)	N	Current tariff	Median	Mean	SD	Current tariff	Median	Mean	SD
5	246	100	200	272	270	0.21	0.41	0.56	0.56
10	244	100	288	423	438	0.11	0.30	0.44	0.45
15	247	260	400	546	542	0.18	0.27	0.38	0.37
20	224	420	400	580	518	0.22	0.21	0.30	0.27
25	168	580	450	680	979	0.24	0.19	0.28	0.40
30	154	740	500	835	909	0.26	0.17	0.29	0.31
Prefer increasing block tariff									
5	120	100	200	269	287	0.21	0.41	0.55	0.59
10	115	100	300	427	432	0.11	0.31	0.44	0.45
15	114	260	325	489	382	0.18	0.22	0.34	0.26
20	105	420	400	520	433	0.22	0.21	0.27	0.22
25	81	580	400	610	779	0.24	0.16	0.25	0.32
30	65	740	500	686	862	0.26	0.17	0.24	0.30
Prefer uniform volumetric tariff									
5	88	100	200	303	282	0.21	0.41	0.62	0.58
10	84	100	300	486	513	0.11	0.31	0.50	0.53
15	86	260	500	673	600	0.18	0.34	0.46	0.41
20	76	420	500	752	669	0.22	0.26	0.39	0.34
25	51	580	500	728	629	0.24	0.21	0.30	0.26
30	49	740	1000	1144	891	0.26	0.34	0.39	0.31

prices reported at each hypothetical water use level for respondents who preferred an IBT (Table 9 and Figure 2). However, the mean implicit average prices are still mostly higher than that under the current tariff. The fair water bill stated by those who prefer the uniform volumetric tariff for the largest quantity (30 m^3/month) is nearly double that of the fair water bill stated by those who prefer an IBT (median of 500 NPR vs 1,000 NPR).

The implicit average water price for households that stated they preferred an IBT decreases as a function of hypothetical water use at the aggregate level. This reflects an inconsistency between the household and aggregated levels. While individual households may state that they support increasing average water prices as a function of water use, when these households' responses are aggregated, the opposite is true – average water prices decrease as a function of water use. The results in Table 9 show that households that express a preference for IBTs, in aggregate, report a 'fair water bill' that implies the implicit price should decrease as volume increases (which is not consistent with an IBT structure).

Table 10 reports the regression results for Equation (3), with four different model specifications. As expected, β_1 is positive and robustly statistically significant across all specifications, confirming that respondents perceive that it is fair for households who use more water to pay more in total. However, β_2 is negative but not statistically significant, suggesting that respondents do not prefer increasing non-linear tariff structures such as IBTs. The last model specification includes preferences for IBTs and the interaction between *ibt* and *hyp_usage_sq*. The coefficient on *ibt* is not statistically significant, but the coefficient on the interaction term is. This implies that a preference for IBTs modifies β_2 negatively, which is the opposite of what we would expect. For those who believe households that use more water should pay increasingly higher water bills, β_2 should be positive. Household income is positively

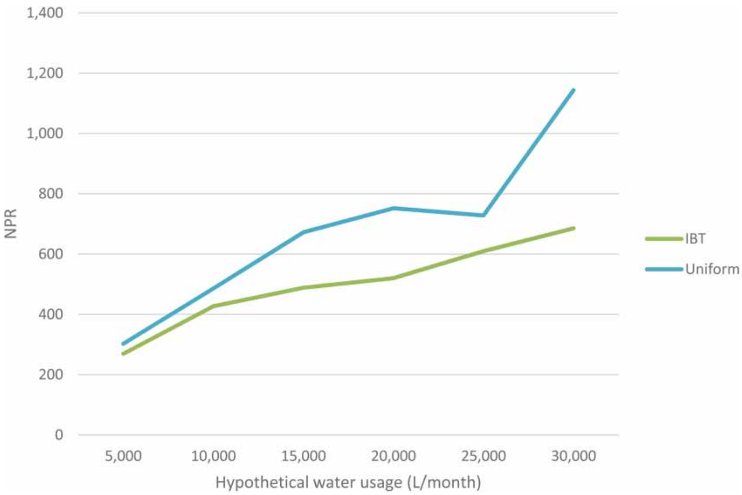

Fig. 2. Fair water bill (NPR).

associated with higher reported fair water bills, as are higher monthly water expenditures. The R^2 values for the model specifications range from 0.12 to 0.18[7].

Our analysis suggests that respondents do not have strong preferences for IBTs or other increasing nonlinear tariff structures. Even though a small majority of respondents (58%) said that they prefer IBTs to uniform volumetric prices in response to a direct question, after controlling for household characteristics and neighborhood unobservables, we find little evidence that households prefer increasing nonlinear tariffs. We believe that many respondents simply wanted cheap, affordable piped water services, and that water bills should be calculated fairly for everyone in Kathmandu, which they do not necessarily associate with an IBT or other increasing nonlinear tariff structure.

Water shortage was clearly a salient problem, with strong, explicitly stated dissatisfaction regarding the level of service and the fairness of distribution. Increases in household water use would occur in bathing, cleaning, and gardening. Household preferences also reflect a strong desire for more affordable water. Households are currently receiving little water from their taps and paying an average of US\$1.75/m^3 (SD 3.47). Implicit average water prices from stated fair bills are significantly lower (see Table 9).

We found that preferences for tariff structure are difficult to associate with socioeconomic variables. Instead, it seems that preferences are driven by desires for cost-minimization and fairness. When it comes to IBTs, the variable with the strongest explanatory power is consideration of what is best for other households. It also seems that households who use less water understand that they will pay less under an IBT. Overall fairness is a large concern, but the interpretation of fairness varies. Those who prefer an IBT believe

[7] Appendix Table A3 presents results for the same set of specifications, but separately for those who prefer an IBT and for those who prefer a uniform volumetric tariff. We find that the relationship between quantity and price (β_1) holds for those who prefer a uniform volumetric tariff, but find no significant relationship (β_1 and β_2) for those who prefer an IBT. Our results are not sensitive to the exclusion of respondents who did not pass the check question on understanding of the IBT concept. Appendix Table A4 presents the results for the entire sample. The sign and significance of key coefficients β_1 and β_2 remain robust. The magnitude of β_1 remains stable at 0.02 across all specifications. Appendix Table A5 modifies the model by including a dummy variable for the initial failure of the check question (*check_understanding*). While the coefficient on the response to the check question is statistically significant, the sign and significance of β_1 and β_2 remain the same.

Table 10. Regressions of fair bill on hypothetical monthly usage.

Variables	(1) fair_bill	(2) fair_bill	(3) fair_bill	(4) fair_bill
hyp_usage	0.0256** (0.0105)	0.0225** (0.0106)	0.0238** (0.0109)	0.0242** (0.0108)
hyp_usage_sq	-1.44×10^{-7} (3.33×10^{-7})	-6.45×10^{-8} (3.37×10^{-7})	-1.04×10^{-7} (3.50×10^{-7})	7.93×10^{-8} (3.19×10^{-7})
ln_income		121.0*** (38.71)	101.0*** (36.27)	106.5*** (35.57)
nhh		−6.776 (9.062)	−9.864 (9.389)	−12.51 (9.036)
resp_edu		1.547 (4.296)	1.088 (4.235)	1.935 (4.468)
resp_illiterate		31.25 (52.18)	35.81 (53.39)	47.61 (53.62)
resp_hhhead		97.02*** (31.74)	86.27*** (30.93)	73.97** (30.21)
ln_monthlywaterexp			32.21*** (10.71)	35.00*** (9.053)
pwc_m3			6.425 (4.389)	3.045 (3.761)
priority_water			−57.20 (35.86)	−57.43 (34.45)
ibt				−55.45 (55.15)
ibtXhyp_usage_sq				-3.21×10^{-7}* (1.68×10^{-7})
Municipality – Lalitpur	−112.3 (67.76)	−86.07 (65.44)	−66.31 (64.42)	−49.13 (58.90)
Municipality – Bhaktapur	−288.1*** (62.37)	−215.1*** (67.57)	−121.2 (98.56)	−96.27 (93.22)
Municipality – Kirtipur	−346.9*** (58.04)	−296.8*** (50.92)	−213.1*** (58.88)	−161.8*** (46.51)
Municipality – Madhyapur Thimi	−154.1** (75.91)	−91.77 (76.43)	−88.40 (76.41)	−53.98 (69.96)
Constant	251.9*** (73.83)	−1,102*** (372.8)	−1,041*** (362.4)	−1,079*** (349.4)
Observations	1,040	1,011	1,011	1,005
R^2	0.116	0.140	0.157	0.177
F-statistic	18.17	12.81	12.00	13.28
Prob > F	0.000	0.000	0.000	0.000

Clustered standard errors in parentheses.
***$p < 0.01$, **$p < 0.05$, *$p < 0.1$.

that people who use less can get a discount and those who consume more should pay higher prices for the extra water they consume. Those who prefer a uniform tariff believe that all customers should pay the same price.

From Figure 2 and Tables 9 and 10, there is evidence for a positive relationship between price and quantity of water. Fair water bills generally increase monotonically as a function of water use. However, subsample analysis (see Appendix Table A3) shows that the significant relationship between quantity and price is driven by those who prefer a uniform volumetric tariff. For those who prefer an IBT, neither β_1 nor β_2 are significant. While there is an overall positive relationship between water use and water price, there is little evidence in support of IBTs.

Conclusions

We find that households are primarily concerned with the perceived fairness of the water tariff structure. Based on their responses about 'fair water bills' for exogenously assigned quantities, households appear to support a water tariff that is a function of the quantity of water used. Importantly, the notion of fairness varies across the population. For those who prefer an IBT, fairness means that people who use less should get a greater discount per unit of water used than those who consume more. In contrast with this position, fairness among those who prefer a uniform tariff means that all customers should pay the same price regardless of the quantity of water they use.

Perhaps surprisingly, there is little evidence that households prefer that water tariffs be structured in a way that ensures poor households have access to sufficient quantities of water at affordable prices. While this is an important objective of consultants, water utility managers, and international donors, our sample households seem more concerned about the price level generally instead of the affordability of piped water services for poor households.

Our multivariate analysis illustrates how household preference for tariff structure can be analyzed and results interpreted. The simple descriptive statistics show that a small majority of respondents (58%) said that they prefer IBTs to uniform volumetric prices in response to a direct question, might lead to a 'naive' conclusion that IBTs are preferred by the most households. But after controlling for household characteristics and neighborhood unobservables, we find little evidence that households have strong preferences for increasing nonlinear tariffs.

Our findings have important implications for the choices over different water tariff structures. One reason IBTs are popular with water utility managers may be that they believe citizens consider IBTs to be fair. Water utility managers may be unaware that their customers may have alternative notions of fairness, and that many may not, in fact, favor IBTs. In most cities in low- and middle-income countries, the volumetric prices in all the blocks of an IBT are below the average costs of service. Our findings are consistent with the hypothesis that this may be due in part to the fact that there may be little customer support for high volumetric prices in the upper blocks.

Water utility managers should take household preferences into account when choosing a tariff structure. However, because household preferences for water tariff structures in Kathmandu are heterogeneous, utility managers may have considerable latitude in choosing a tariff structure that best achieves the utility's objectives of cost recovery and revenue stability. As long as the utility managers focus on and communicate the affordability and fairness of the water tariff, they should be able to garner public support for tariff reforms.

Finally, we suggest that there is a need for further empirical research on households' notions of fairness and social justice and how households assess the consequences of changes in both tariff structures and price levels in terms of these criteria. Additionally, as this study did not examine household preferences about sizes and prices of blocks in an IBT, future work is needed to more clearly understand both individual and aggregate preferences about more detailed features of IBTs.

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Supplementary material

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