Econometrica Supplementary Material

SUPPLEMENT TO "THE VALUE OF FREE WATER: ANALYZING SOUTH AFRICA'S FREE BASIC WATER POLICY"

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This supplement, not intended for publication, contains further details on the data and analysis presented in the paper.

S1. DETAILS ON THE SURVEY

THE GOAL OF THE SURVEY was to collect information on water usage and household demographics to complement the administrative data provided by Odi Water. The survey included 21 questions about, for example, the number and type of water-using fixtures used by each household, the lot size and landscape characteristics, relevant irrigation methods and habits, other exterior uses of water, water conservation actions taken, and household demographics such as family size, education levels, and income.

The survey was entirely funded by the University of Houston. It was approved by the Human Subject Committee of the University of Houston, and was conducted in accordance with the standards of that institution regarding the ethical treatment of human subjects. Participation in the survey was voluntary and respondents could stop participating in the survey at any time. Each questionnaire took about 30 minutes to complete. Only adults between the ages of 18 and 65 were asked to participate.

S1.1. *Sampling*

The objective of the sampling design was to yield a sample that is representative of the surveyed population, the residential consumers of Odi Water, based on information that was available prior to the survey. This included monthly water consumption, indigent status, whether the consumer was restricted, and the supply area. These variables were used to define 96 strata in the population, and a stratified random sample was taken. At the time of the survey, December 2008 was the last monthly billing cycle for which information on Odi Water's consumers was available, and the sampling was therefore designed to be representative of that population. To reach my target sample size of 1000, I took an initial sample of 1000 households. The survey team was instructed to interview each of the 1000 households in this sample. If a household could not be reached after two attempts or if the respondent declined to answer, it was replaced by a random household from the un-sampled population of consumers belonging to the same stratum as the original household.

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If that household could not be reached or declined to answer, it would be replaced by a third household from the same stratum, and so on. This procedure ensured that the resulting sample was representative of the surveyed population. In practice, 177 households were replaced once, 29 twice, and 9 three times before the data collection ended. The final sample size is 1000 households.

S1.2. *Data Collection*

The survey was carried out by Impact Research International, Inc. (IRI), a survey and market research company based in Pretoria, under the supervision of the author. Surveyors with extensive local experience were trained by IRI and the author specifically for the purpose of this project. These surveyors visited each household at their home address and asked and recorded the questions to the questionnaire provided by the author. Interviews were performed in either English or a local language (all interviewers were fluent in all the relevant local languages), and the questionnaire itself was available in all the relevant languages. The completed questionnaires went through a quality check by the staff at IRI and by the author, and were entered into a computer database. After a pilot survey on November 25, 2010, data collection took place between November 29, 2010 and February 2, 2011.

Throughout the process, we ensured that the survey was performed independently from the personnel at Odi Water or the municipality. Surveyors introduced themselves to respondents as working under contract for the University of Houston. The separation of individual consumption information (including account numbers) and survey responses was maintained throughout the survey. The final database identifies respondents by a code generated by the author, and does not contain the billing account number, service address, or name of the customers.

S1.3. *Sample Properties*

Table S-I contains the main characteristics of the sample based on the latest information in Odi Water's records (December 2008). Approximately 11% of the respondents have indigent status and receive a free water allowance of 12 kl per month. Nineteen percent of the households are restricted. Average household consumption is 12.95 kl per month. The respondents live in three distinct supply areas based on Odi Water's definition. The table also shows the composition of surveyed population. As can be seen, the sample is representative with respect to the household characteristics available prior to the survey.

TABLE S-I

SAMPLE PROPERTIES[a]

	All Consumers December 2008	Survey Full Sample
Indigent (%)	11	11
Restricted (%)	19	19
Sanitation (%)	85	86
Supply area 1 (%)	31	30
Supply area 2 (%)	21	21
Supply area 3 (%)	48	49
Average consumption (kl/month)	12.95	12.1
Monthly consumption		
4 kl or less (%)	25.6	25.2
5–8 kl (%)	24.7	25.3
9–14 kl (%)	23.9	26.5
15 or more kl (%)	25.8	23
Number of observations	46,214	1000

[a]The table compares the distribution of consumer characteristics in the population and the survey sample.

S2. PHOTOS FROM THE PROJECT

Figures S2 and S2 illustrate the study area. Typical properties in the area are relatively small; the average household size is 4.3 persons. Many housing units are uniform single-family buildings provided by the government with limited modifications made by the residents. Thus, living conditions are fairly similar within the sample.

FIGURE S1.—Water meter.

FIGURE S2.—Typical housing unit and infrastructure in the sample.

Each participating household has water-using sanitation and tap(s) inside the house or outside on the property. Consumption is metered individually by a meter located on the property and easily accessible to the household.

S3. ADMINISTRATIVE DATA

S3.1. *Water Consumption Data*

This section describes cleaning of the administrative consumption data and how the final data set was generated. The final data set includes 3,036,871 monthly observations, and was generated as follows. I dropped from the data Odi Water's commercial and institutional consumers (5.6% of the data). I also dropped accounts showing zero consumption.[1] The employees of Odi Water inspect the water meter each month at meter-reading. If there is a problem with the meter, employees record the code of the problem which is also included in my data set.[2] In addition, the meter reader tests the tap for any water leaks and reports the problem. I drop observations with *any* problems reported (1.7%). Because of the regular quality checks, illegal tapping in this area is virtually non-existent, in contrast to many other developing countries or even other parts of South Africa.

Based on my conversations with Odi Water officials, the utility has difficulty distinguishing commercial and residential consumers if the consumer is running a small business from home. These small businesses include hair salons, car washing facilities, small restaurants, etc. Since Odi Water made efforts to identify these households and re-categorize them as commercial units, there are several account numbers whose status changed from domestic to commercial during the observed period. I drop the entire accounts with changing status from the sample (less than 0.2%). I also drop areas which are categorized as agricultural since water pricing and supply is different than in the rest of the supply areas (3.7%). Lastly, I drop observations where monthly consumption is higher than 50 kl, which is four times the average consumption (an additional 3.4%). These consumption levels are most likely associated either with unreported leaks or with commercial activities not yet categorized as such by Odi Water. In the final data set, average monthly consumption is 13.2 kl.

Table S-II presents detailed information on the distribution of consumption across all tariff schedules in the data. Twenty-eight point three percent of the

TABLE S-II

DISTRIBUTION OF CONSUMERS BY TARIFF SEGMENT[a]

Tariff Segment	% of Consumers	*N*
Segment 1 (1–6 kl)	28.32	859,931
Segment 2 (7–12 kl)	29.26	888,575
Setment 3 (13–18 kl)	18.86	572,784
Segment 4 (19–24)	10.73	325,789
Segment 5 (25–30)	5.88	178,524
Segment 6 (31–42)	5.08	154,219
Other segments (43+ kl)	1.88	57,049

[a]The table shows the distribution of consumption levels in the population across eight tariff years. A tariff segment is a consumption interval that is assigned the same unit price in the tariff schedule. $N = 3{,}036{,}871$.

[1]In some cases, zero consumption refers to vacant land, closed accounts, etc., a total of 489,959 monthly observations.

[2]These problems include the following: dirty dial, meter covered, meter stuck, meter damaged, meter dial is missing, meter tampered with, meter obstructed, water leak, or meter removed.

TABLE S-III

SANITATION MULTIPLIER, 2002–2009[a]

Water Consumption in kl	Sanitation Multiplier
0–6	0.98
7–12	0.9
13–18	0.75
19–24	0.6
25–30	0.52
31–42	0.1
42+	0.01

[a]The table shows sanitation multipliers for different price segments. These determine the quantity after which sanitation charges are billed.

households consume below 6 kiloliters, which is the free allowance under most tariff schedules. Seventy-six point five percent of all observations are concentrated on the first three price blocks (up to 18 kl).

S3.2. *Tariffs*

Table S-III shows the sanitation multipliers included in the prices. Table S-IV presents summary statistics of the tariff schedules.

TABLE S-IV

SUMMARY STATISTICS, TARIFF STRUCTURE, 2002–2009, 2008 RAND[a]

Variable	Units	Mean	Std. Dev.	Min	Max
Marginal price in block 1	Rand/kl	1.59	2.89	0	7.18
Marginal price in block 2	Rand/kl	9.96	1.93	3.67	11.78
Marginal price in block 3	Rand/kl	10.54	1.34	6.47	11.86
Marginal price in block 4	Rand/kl	10.38	1.37	6.53	12.28
Marginal price in block 5	Rand/kl	10.39	1.53	6.61	12.99
Marginal price in block 6	Rand/kl	9.10	1.72	6.69	12.02
Marginal price in block 7	Rand/kl	9.17	1.97	6.76	12.86
Marginal price in block 8	Rand/kl	11.32	1.46	8.96	12.91
Water quantity at kink 1	kl	6.00	0.05	6	12
Water quantity at kink 2	kl	12.00	0.05	12	18
Water quantity at kink 3	kl	18.00	0.05	18	24
Water quantity at kink 4	kl	24.83	3.77	24	42
Water quantity at kink 5	kl	31.93	8.80	30	72
Water quantity at kink 6	kl	42.00	0.24	42	72
Water quantity at kink 7	kl	75.68	7.26	72	90

[a]The table shows summary statistics of the price schedules (marginal prices and kink points) observed throughout the study period.

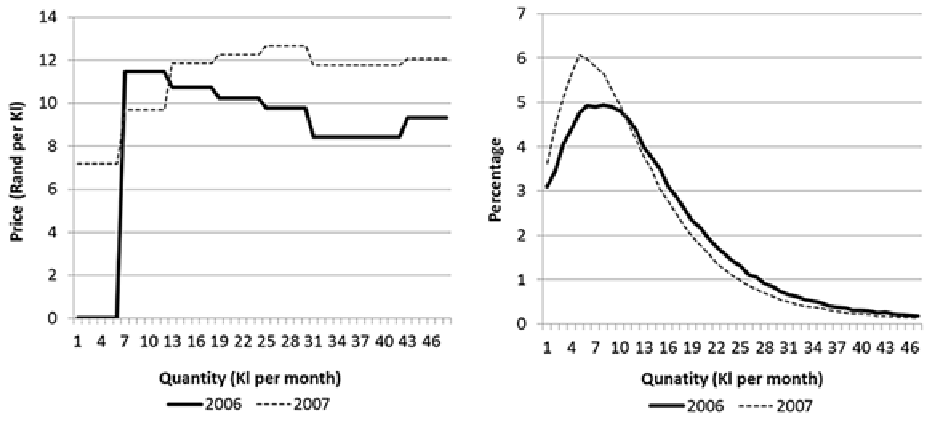

FIGURE S3.—Policy change for non-indigent households, 2006–2007. *Notes*: The left panel shows the change in the marginal prices for non-indigent households. The right panel shows the corresponding change in the consumption distribution.

Figures S3 and S4 show the policy change in 2007, when the utility created separate tariff structures for registered indigent households. The left panels show the change in the tariffs. The right panels show the corresponding change in the consumption distribution.

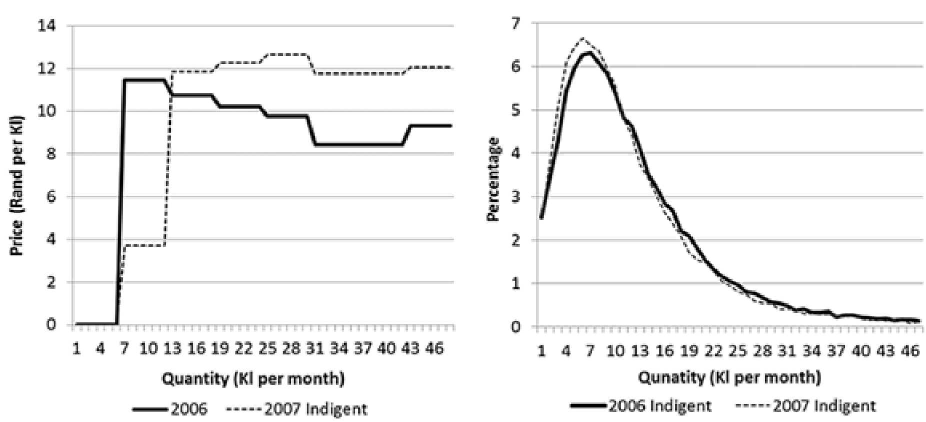

FIGURE S4.—Policy change for indigent households, 2006–2007. *Notes*: The left panel shows the change in the marginal prices for indigent households. The right panel shows the corresponding change in the consumption distribution.

S4. PATTERNS IN THE DATA

S4.1. *Distribution of Consumption Over Time*

Figures S5–S7 present various comparisons of consumption distributions over time. The figures compare the distribution of quarterly average consumption with the same quarter of the previous tariff year. Tariffs are revised starting in July of every year, so quarter 1 refers to July–September. Comparing the same quarters across years helps filter out any seasonality of water consumption in the raw data. Figure S5 focuses on tariff years 6 and 7, when the biggest tariff change occurred. Figure S8 shows the monthly distribution for these two years. These figures provide suggestive evidence that consumers respond to revisions of the price schedule in successive tariff years, perhaps with a lag of a month or two. Figures S9 and S10 show the distribution across price blocks by indigent status.

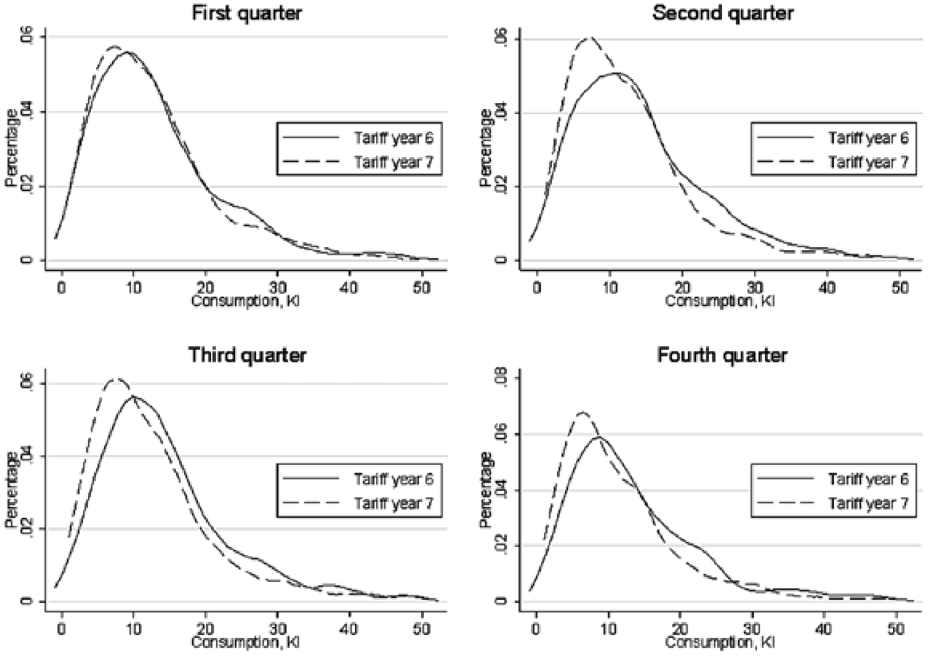

FIGURE S5.—Distribution of quarterly average consumption before and after the 2007 policy change. *Notes*: The figure presents densities of average consumption levels for each quarter of tariff years 6 and 7. Quarter 1: July–September, Quarter 2: October–December, Quarter 3: January–March, Quarter 4: April–June.

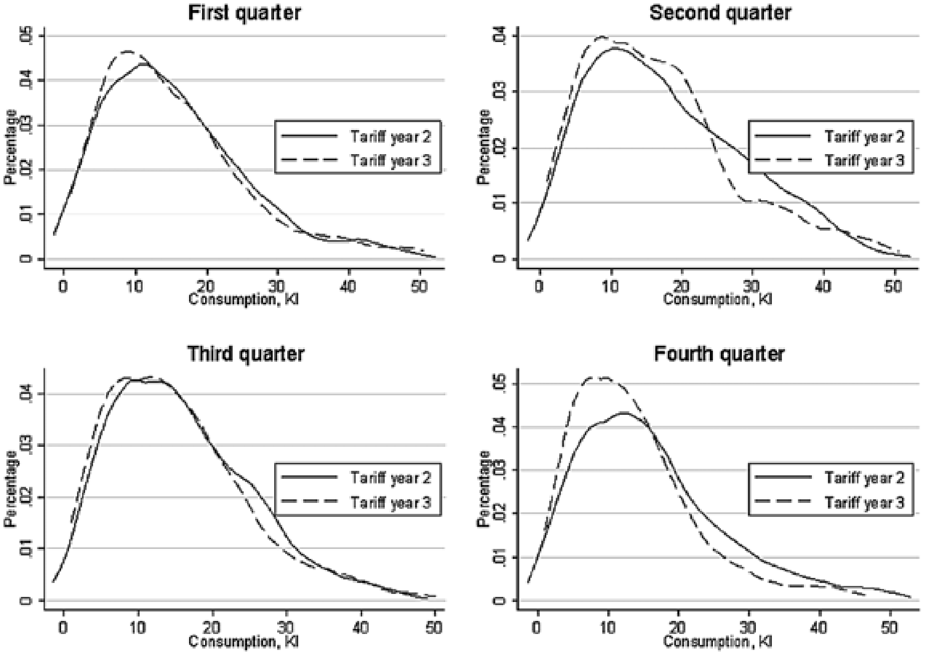

FIGURE S6.—Distribution of quarterly average consumption in tariff year 2 and 3. *Notes*: The figure presents densities of average consumption levels for each quarter of tariff years 2 and 3. Quarter 1: July–September, Quarter 2: October–December, Quarter 3: January–March, Quarter 4: April–June.

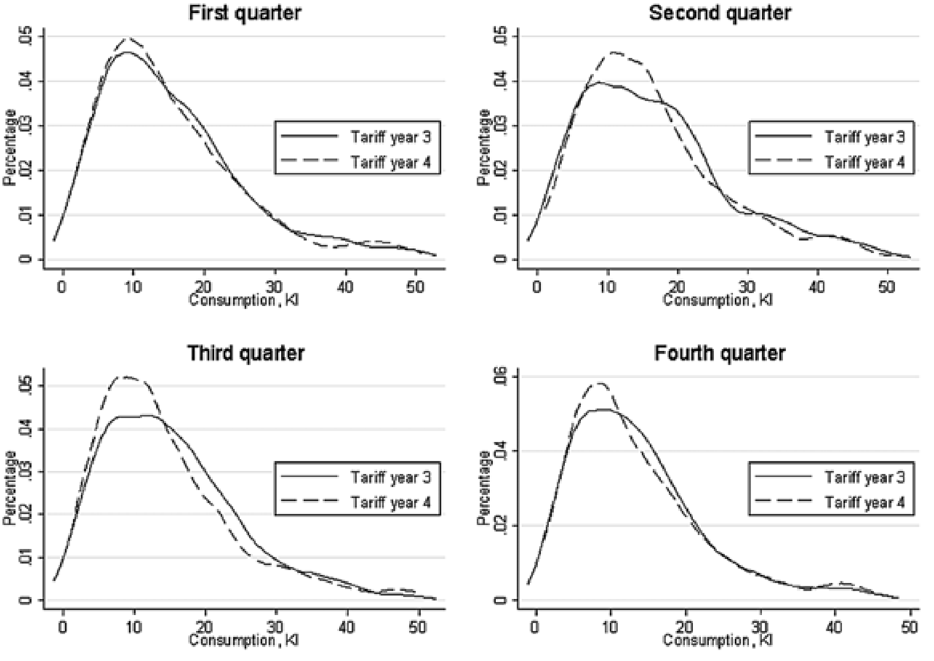

FIGURE S7.—Distribution of quarterly average consumption in tariff year 3 and 4. *Notes*: The figure presents densities of average consumption levels for each quarter of tariff years 3 and 4. Quarter 1: July–September, Quarter 2: October–December, Quarter 3: January–March, Quarter 4: April–June.

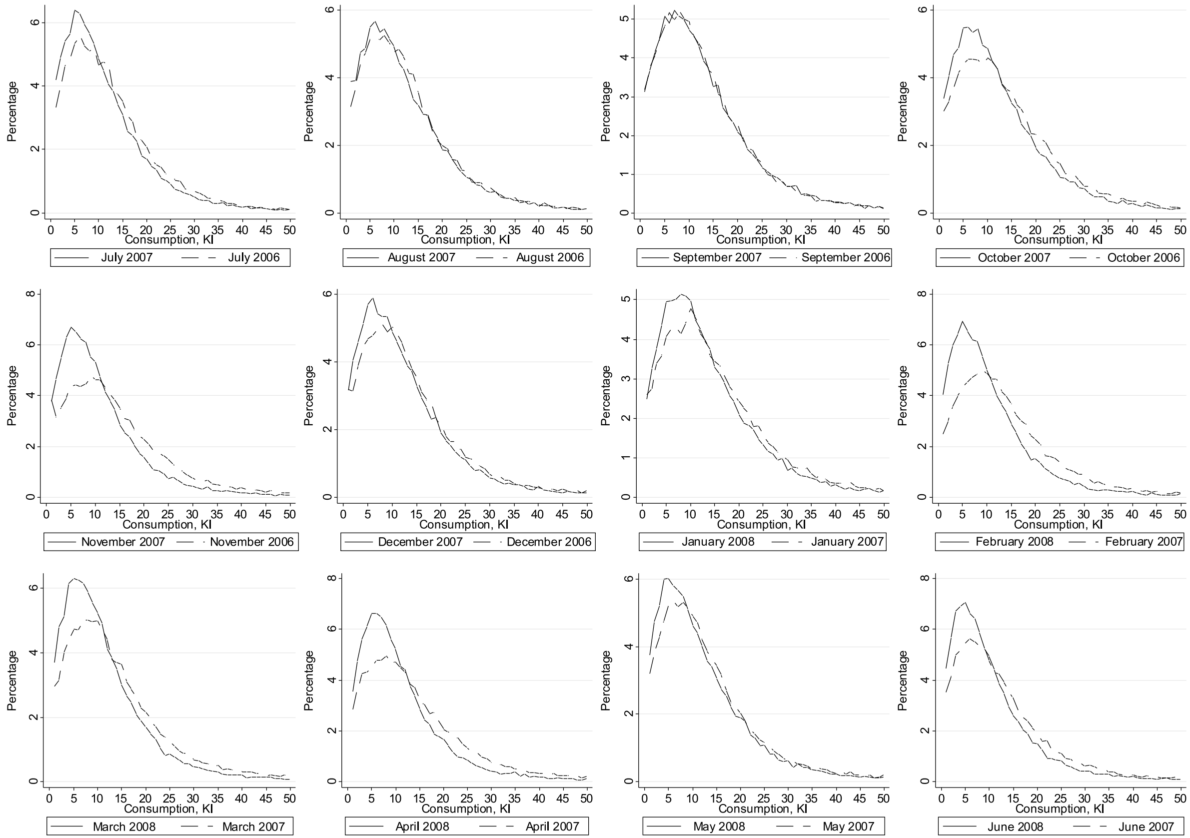

FIGURE S8.—Monthly consumption distribution in tariff year 6 and 7. *Note*: The figure presents densities of consumption levels in each month in tariff year 6 and 7.

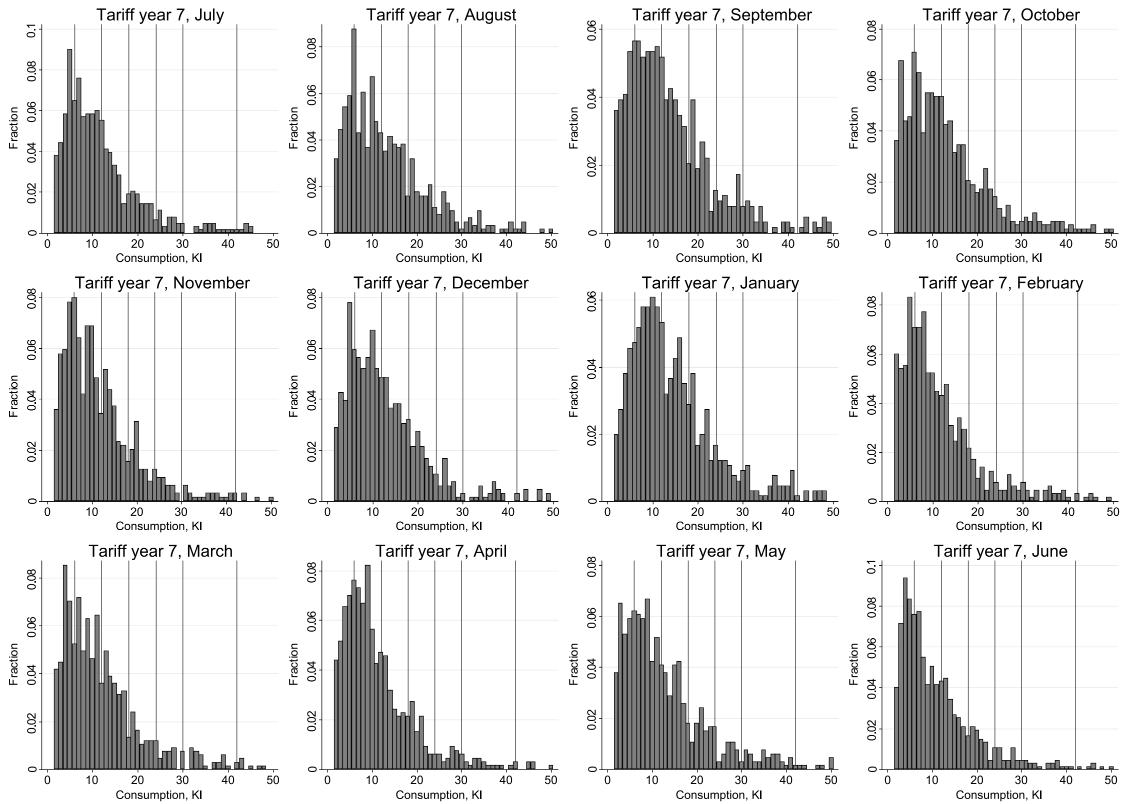

FIGURE S9.—Consumption distribution across price blocks, tariff year 7, only non-indigent households. *Notes*: The figure presents histograms of consumption levels in each month of tariff year 7. Each bar corresponds to a 1 kl increment in consumed quantity. Vertical lines represent the kink points of each tariff schedule.

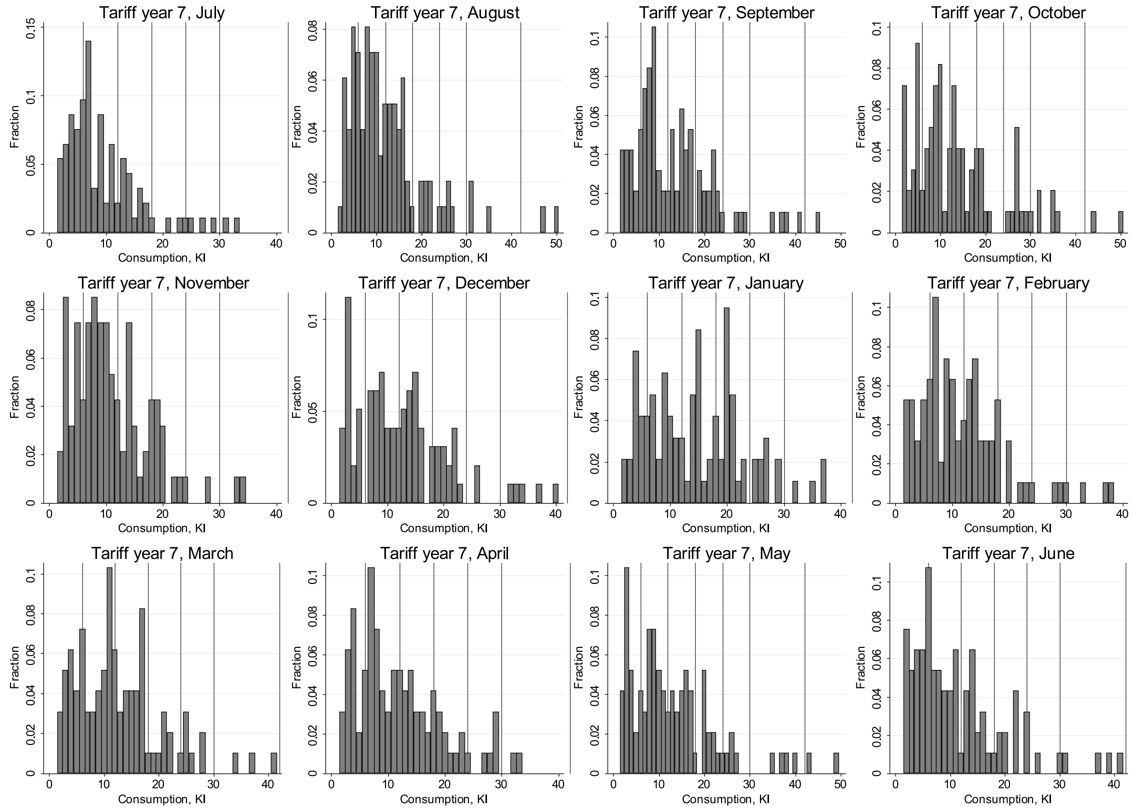

FIGURE S10.—Consumption distribution across price blocks, tariff year 7, only indigent households. *Notes*: The figure presents histograms of consumption levels in each month in tariff year 7. Each bar corresponds to a 1 kl increment in consumed quantity. Vertical lines represent the kink points of each tariff schedule.

S4.2. *Detailed Regression Table*

Column (1) of Table S-V shows the OLS demand estimate referred to in Section 3.2 in the main text. Columns (2)–(5) present the detailed regression output corresponding to the first row of Table II in the main text.

TABLE S-V
WATER DEMAND REGRESSIONS[a]

Variables	(1)	(2)	(3)	(4)	(5)
Price	1.948	−0.620	−0.608	−0.551	−0.554
	(0.009)	(0.024)	(0.024)	(0.023)	(0.023)
Income $\times 10^{-4}$	1.151	2.307	1.081	0.230	0.875
	(0.075)	(0.112)	(0.150)	(0.146)	(0.118)
Indigent	2.531	−2.172	−2.396	−1.503	−1.262
	(0.075)	(0.143)	(0.141)	(0.137)	(0.134)
Sanitation	−3.337	−0.366	−0.012	−1.095	2.543
	(0.119)	(0.176)	(0.177)	(0.175)	(0.157)
Average max daily temperature (°F)	0.103	0.105	0.105	0.104	0.104
	(0.005)	(0.007)	(0.007)	(0.007)	(0.007)
Supply area 1	−1.412	−1.965	−1.749	−1.449	
	(0.071)	(0.100)	(0.099)	(0.098)	
Supply area 2	−2.065	−6.284	−5.982	−4.778	
	(0.099)	(0.142)	(0.141)	(0.144)	
Restricted	1.128	1.058	0.882	1.167	1.369
	(0.079)	(0.118)	(0.116)	(0.113)	(0.114)
Number of flush toilets				0.633	
				(0.095)	
Number of standpipes				−0.474	
				(0.046)	
Number of bathtubs				1.582	
				(0.093)	
Number of showers				0.684	
				(0.141)	
Number of kitchen taps				−0.427	
				(0.093)	
Number of bathroom taps				1.381	
				(0.069)	
Washing machine				0.680	0.781
				(0.093)	(0.091)
Lawn area				1.081	
				(0.104)	

(*Continues*)

TABLE S-V—*Continued*

Variables	(1)	(2)	(3)	(4)	(5)
Flower garden				−0.554 (0.100)	
Vegetable garden				1.107 (0.118)	
Winter irrigation				0.336 (0.058)	
Summer irrigation				−0.226 (0.050)	
Washes car				−0.085 (0.050)	
Some high school			1.635 (0.172)	1.948 (0.167)	
High school graduate			1.029 (0.162)	1.043 (0.156)	
Some higher education			1.288 (0.182)	0.918 (0.176)	
Completed higher education			3.138 (0.206)	2.054 (0.196)	
Number of adults			1.076 (0.036)	0.983 (0.036)	
Number of teens			−0.114 (0.047)	0.109 (0.048)	
Number of children			−0.041 (0.046)	−0.104 (0.046)	
Number of people working outside the home			−0.077 (0.067)	−0.478 (0.066)	
Number of persons on the property					0.391 (0.020)
Outdoor water usage					0.438 (0.043)
Bathtub or shower					4.102 (0.094)
Completed high school or higher					−0.431 (0.095)
Constant	−1.102 (0.357)	9.857 (0.531)	5.779 (0.547)	4.156 (0.533)	0.887 (0.506)

[a]The dependent variable is monthly consumption in kl. ‘Price’ is the average price corresponding to this consumption. Column (1) is an OLS regression, (2)–(5) are IV regressions where price is instrumented by the marginal prices at the six most common kink points (6, 12, 18, 24, 30, and 42 kl). ‘Supply area’ denotes a geographic area. ‘Outdoor water usage’ indicates how many of the following the household owns (0–3): vegetable garden, flower garden, lawn area. ‘Bathtub or shower’ is 1 if the household owns a bathtub, a shower, or both, and 0 otherwise. Robust standard error in parentheses. $N = 63{,}178$.

S4.3. *Regressions Using Lagged Tariffs*

This section presents further evidence on consumers' responsiveness to price changes. Specifically, for each month, I compute the average price faced by the household based both on the current tariff schedule as well as the tariff schedule from the previous year. I then regress consumption on the current and the previous average price, using the marginal prices of each tariff schedule as instruments, and controlling for household characteristics. I do this for all months, as well as taking averages within each quarter and restricting the sample to the same quarter in every tariff year. Both current and past average prices are instrumented with the marginal prices (as descibed in the main text, Section 3.2).

Table S-VI shows the coefficient estimates on current and lagged average prices from these regressions (in each case, the sample contains only non-indigent households with sanitation). When all months are included, the current and lagged average prices are both significant with the expected negative sign. The coefficient on the current price is twice as large as the one on the lagged price, indicating that consumption responds more to the current tariff schedule. A similar pattern is observed when restricting the sample to the first quarter in every tariff year. In the second quarter, the coefficient on the lagged price is only 1/5th of the current price coefficient, and it is not statistically significant. The results in the fourth quarter show a similar picture, with the lagged price coefficient close to zero. The third quarter is the only one showing a larger effect of the lagged price, but the coefficient on the current price becomes positive in this case, making this particular regression hard to interpret. Overall, these patterns echo those seen in the raw data, with consumption becoming more responsive to the new tariff later in the tariff year.

TABLE S-VI

LAGGED TARIFF REGRESSIONS[a]

	All	Q1	Q2	Q3	Q4
Price in t	−0.398***	−0.329***	−0.419**	0.041	−0.314***
	(0.029)	(0.092)	(0.196)	(0.132)	(0.087)
Price in $t-1$	−0.332***	−0.202*	−1.101**	−0.458*	−0.275
	(0.043)	(0.112)	(0.442)	(0.252)	(0.283)

[a]The dependent variable is monthly consumption in kl. 'Price' is the average price corresponding to this consumption based on the current (t) or previous ($t-1$) price schedule. Prices are instrumented by the marginal prices at the six most common kink points (6, 12, 18, 24, 30, and 42 kl). Q1–Q4 restrict the sample to observations from specific quarters. The estimation sample contains non-indigent households with sanitation. Robust standard errors in parentheses. $N = 63{,}178$.

S5. DETAILS ON THE ESTIMATION PROCEDURE

S5.1. *Steps of the Estimation Procedure*

The demand estimation procedure described in the paper is computationally complex. The following describes the step by step instructions to estimate the demand function in the case of a mixture of increasing and decreasing tariffs. The procedure can be implemented in MATLAB or using similar software.

The following steps should be iterated from initial starting values for the parameters $(\alpha, \gamma, \delta, \sigma_\eta, \sigma_\varepsilon)$ using any minimization procedure until convergence is achieved.

1. Compute the following for each individual:

(a) For each tariff segment k: Y_k^0, $w_k^0 = Z\delta + \alpha P_k + \gamma Y_k^0$, and $\theta_{jk} = \bar{w}_j - w_k^0$, as well as $\bar{\eta} \equiv \min_k(-w_k^0 - \frac{\alpha}{\gamma})$.

(b) *Compare segments to segments*. For each pair of segments i and j: η_{ij}^s which solves $V(P_i, Y_i^0) = V(P_j, Y_j^0)$. Given the functional forms, η_{ij}^s has a closed form solution and is unique.

(c) *Compare convex kink points to convex kink points*. For each pair of convex kink points i and j: η_{ij}^k which solves $U(\bar{w}_i) = U(\bar{w}_j)$. Given the functional forms, η_{ij}^k has a closed form solution and is unique.

(d) *Compare segments to convex kink points*. For each convex kink i and segment $j \neq i \pm 1 : u_{ij}^L < u_{ij}^U$ which are the two roots of the equation $U(\bar{w}_i) = V(P_j, Y_j^0)$ in η. Given the functional forms, for given i and j, there are a maximum of two roots which can be computed numerically (no closed form solution).

To make sure that a root exists, I first compute the value of η for which $\partial V/\partial\eta = \partial U/\partial\eta$. Equation $U(\bar{w}_i) = V(P_j, Y_j^0)$ has two roots iff at this value of η, $V_j < U_i$, in which case I proceed to compute the roots numerically starting the search from a sufficiently low or from a sufficiently large starting point. If $V_j > U_i$ for this value of η, then $U(\bar{w}_i) \leq V(P_j, Y_j^0)$.

2. Establish the feasibility conditions for each segment and kink as described in Eq. (9) in the paper, using θ_{jk} calculated in 1(a).

3. Combine the feasibility and optimality conditions for each segment and kink, as described in Section 5.1 in the paper, by taking the maximum of the lower bounds and the minimum of the upper bounds. Denote these values (L_k, H_k) and (l_k, h_k) for segments and kinks, respectively.

4. Substitute in the likelihood function as described in Appendix A.3.

5. Choose δ, α, γ, σ_η, and σ_ε to minimize the objective function. Iterate.

S5.2. *Consistency*

Let $W = (W_1, \ldots, W_N) \in \Theta$ denote the sequence of observations on the data and let G_N be the empirical distribution of W. Let $L(b, W)$ denote the loglikelihood function derived in Appendix A.3, where $b = (\delta, \alpha, \gamma, \sigma_\eta, \sigma_\varepsilon) \in B$ denotes the vector of parameters to be estimated.

Manski (1988, Theorem 2′) showed that the maximum likelihood estimator of b is consistent provided the following conditions hold:

CONDITION 1: There is a unique $b \in B$ for which $b = \arg\max_{c\in B} \int_\Theta L(c, W)\, dG$.

CONDITION 2: $L(\cdot, W)$ is continuous on B for all $W \in \Theta$.

CONDITION 3: There exists an integrable function $D : \Theta \to [0, \infty)$ for which $|L(c, W)| \leq D(W)$ for all $(c, W) \in B \times \Theta$.

CONDITION 4: B is compact.

CONDITION 5: The observations W_i, $i = 1, \dots, \infty$ are independent realizations from G.

Condition 1 states that the parameters $(\delta, \sigma_\varepsilon, \sigma_\eta)$ are identified. This requires the assumption that the model (hence the conditional densities in the likelihood function) is well-specified. If this holds, as explained in the text, σ_ε and σ_η are identified from variation in consumption within and across segments (or kinks). Note that if the distribution of η is well-specified, it contains household-level heterogeneity without incurring an incidental parameters problem. In particular, household-level fixed effects are not estimated.

Condition 2 states that the likelihood function is continuous. In fact, as Manski (1988, Chapter 7.3) showed, this assumption can be relaxed to requiring that points of discontinuity have zero probability. Inspection of (20) shows that continuity of the likelihood function is satisfied.

Condition 3 is the condition for the Lebesgue dominated convergence theorem. In the standard case when the likelihood function is differentiable, this theorem guarantees that integration and differentiation of the likelihood function can be interchanged, which is used to show that the expected score is zero under the true parameters (e.g., Greene (2002, p. 475)). An important class of problems for which this condition fails is when the support of the dependent variable depends on the parameters. In my case, this might appear to be a problem because the support of η depends on the parameters due to the assumed truncation. However, note that the dependent variable also contains the optimization error ε which is distributed normally. Thus, the support of W is $(-\infty, +\infty)$ regardless of the parameters.

Finally, Conditions 4 and 5 are conditions on the parameter space and the sample which we assume to hold. Note that this theorem does not require the differentiability of the likelihood function.

S5.3. *Uniqueness of the Demanded Quantity for any* η

As long as preferences are convex, we know that demand exists and is unique for any kinked budget. (More precisely, uniqueness is true "almost surely," ignoring the case when a convex indifference curve has two tangency points with a non-convex part of the budget. Not to deal with this situation is standard.) This means that demand is unique for any η, and it is either w_1^0, $\bar{w}_1$, w_2^0, or w_3^0, since these are all the possibilities under the specific three-part budget considered here. The conditions given in (S1) are necessary for each of these cases to obtain:

$$
w = \begin{cases} w_1^0 & \text{if} \begin{cases} \text{(i) } w_1^0 < \bar{w}_1 \text{ and} \\ \text{(ii) } V(P_1, Y) \geq V\big(P_3, Y_3^0\big) \quad \text{if } w_3^0 > \bar{w}_2, \end{cases} \\ \bar{w}_1 & \text{if} \begin{cases} \text{(i) } w_2^0 < \bar{w}_1 < w_1^0 \text{ and} \\ \text{(ii) } U(\bar{w}_1) \geq V\big(P_3, Y_3^0\big) \quad \text{if } w_3^0 > \bar{w}_2, \end{cases} \\ w_2^0 & \text{if} \begin{cases} \text{(i) } w_2^0 \in [\bar{w}_1, \bar{w}_2] \text{ and} \\ \text{(ii) } V\big(P_2, Y_2^0\big) \geq V\big(P_3, Y_3^0\big) \quad \text{if } w_3^0 > \bar{w}_2, \end{cases} \\ w_3^0 & \text{if} \begin{cases} \text{(i) } w_3^0 > \bar{w}_2 \text{ and} \\ \text{(ii) } V(P_1, Y) < V\big(P_3, Y_3^0\big) & \text{if } w_1^0 < \bar{w}_1 \text{ and} \\ \text{(ii}'\text{) } V\big(P_2, Y_2^0\big) < V\big(P_3, Y_3^0\big) & \text{if } w_2^0 \in [\bar{w}_1, \bar{w}_2] \text{ and} \\ \text{(ii}''\text{) } U(\bar{w}_1) < V\big(P_3, Y_3^0\big) & \text{if } w_2^0 < \bar{w}_1 < w_1^0. \end{cases} \end{cases} \tag{S1}
$$

Each condition has two parts: (i) feasibility (consumption on the budget), and (ii) optimality (higher utility than the three other possibilities if they are feasible). In most cases, (ii) can be simplified, as done in (S1). For example, w_1^0 is demanded iff it is feasible and yields higher utility than $\bar{w}_1$, w_2^0, and w_3^0. In this case, feasibility of w_1^0 implies that neither $\bar{w}_1$ nor w_2^0 is feasible, so optimality simplifies to $V(P_1, Y) \geq V(P_3, Y_3^0)$. Clearly, these conditions are mutually exclusive (because of the optimality conditions). Therefore they are also sufficient for each case to obtain.

I now illustrate this with the specific functional forms resulting in Eq. (10) in the paper. That is, I show that, for any η, (10) uniquely defines a demanded quantity (without gaps or overlaps). Under convexity, we know that

$$\theta_{11} < \theta_{12} < \theta_{22},$$

where the second inequality follows from $\bar{w}_1 < \bar{w}_2$, and the first from the fact that $w_2^0 - w_1^0 = (P_2 - P_1)(\alpha + \gamma\bar{w}_1) < 0$ since $P_2 > P_1$ and $\alpha + \gamma\bar{w}_1 < 0$ from convexity. We do not know anything about θ_{23}, since w_3^0 can be anywhere on the extended budget constraint with P_3. Thus, there are four possible scenarios:

$$\theta_{23} < \theta_{11} < \theta_{12} < \theta_{22},$$
$$\theta_{11} < \theta_{23} < \theta_{12} < \theta_{22},$$
$$\theta_{11} < \theta_{23} < \theta_{12} < \theta_{22},$$
$$\theta_{11} < \theta_{12} < \theta_{22} < \theta_{23}.$$

Consider the first one, and check that, for each possible η, (10) gives exactly one solution (and we can do the same for the other three scenarios). Denote the conditions in (10) for demand to be on the first segment, the kink, or the two other segments S1, K1, S2, and S3.

When $\theta_{23} < \theta_{11} < \theta_{12} < \theta_{22}$, we have the following possibilities (summarized in Figure S11):

If $\eta < \theta_{23}$: Only S1 holds (and since $\theta_{23} < \eta$ does not hold, the value of η_{13} is irrelevant). Observed consumption is predicted to be $w_1^0 + \eta + \varepsilon$.

If $\theta_{23} < \eta < \theta_{11}$: First part of S1 and S3 holds. If $\eta < \eta_{13}$, observed consumption is $w_1^0 + \eta + \varepsilon$. If $\eta > \eta_{13}$, observed consumption is $w_3^0 + \eta + \varepsilon$. Note that the second and third "and" in S3 are irrelevant since $\eta < \theta_{11}$.

If $\theta_{11} < \eta < \theta_{12}$: First part of K1 and S3 holds. Observed consumption is $\bar{w}_1 + \varepsilon$ if $\eta \in (u_{13}^L, u_{13}^U)$ and $w_3^0 + \eta + \varepsilon$ otherwise. The first and third "and" in S3 are irrelevant.

If $\theta_{12} < \eta < \theta_{22}$: First part of S2 and S3 holds. Observed consumption is $w_2^0 + \eta + \varepsilon$ if $\eta < \eta_{23}$ and $w_3^0 + \eta + \varepsilon$ otherwise. The first and second "and" in S3 are irrelevant.

If $\eta > \theta_{22}$: Only the first part of S3 holds, that is, $\theta_{23} < \eta$. The other parts of S3 are irrelevant. Observed consumption is $w_3^0 + \eta + \varepsilon$.

Figure S11 summarizes the consumer's observed consumption as a function of η for this scenario. The other three scenarios can easily be checked in the same way.

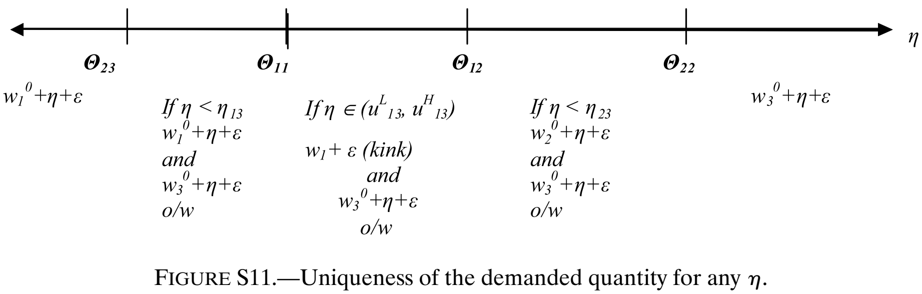

FIGURE S11.—Uniqueness of the demanded quantity for any η.

TABLE S-VII

EXPENDITURE CATEGORIES OF ODI WATER, THOUSAND RAND[a]

Bulk Water Purchase	71,653
Employee Cost	64,375
Operational Expenses	152,337

[a]All data are from the 2010/2011 financial report of Odi Water (Odi Water Services (2011)). The document contains three major expenditure categories.

S6. COMPUTING THE MARGINAL COST OF WATER

All data are from the 2010/2011 financial report of Odi Water (Odi Water Services (2011)). The document contains three major expenditure categories (p. 12), which are shown in Table S-VII.

Employee Cost and Operational Expenses are unlikely to be directly connected to how much water is supplied to the households. It is difficult to judge how many new employees, if any, would need to be hired to provide more water to the same households; similarly, operational expenses include items like maintenance of the infrastructure, operating treatment facilities, etc., all of which are more closely related to the number of connections than to the volume of water supplied to these connections. In line with this interpretation, in the previous financial year, Odi Water purchased about 20% more bulk water, but had lower operational and employee costs.

Based on this, I compute the marginal cost of water in two alternative ways: first, I base it only on bulk water purchases; second, as a more "conservative" measure, I also include half of the operational expenses.

1. Marginal cost based on bulk water only

Odi Water receives almost all of its bulk water from Rand Water (a national bulk water supplier). Rand Water charges uniform water prices and Odi Water's water demand from Rand is negligible at a national scale so it is unlikely to affect this price. Based on the report (p. 16), Odi Water purchased 18,122,933 kiloliters of water in this fiscal year. I divide the cost of bulk water with this quantity to get the marginal cost of water, which is 4.0 Rand.

2. Marginal cost based on bulk water and operational costs

I take the marginal cost based on bulk water and add half of the operational costs divided by the amount of water purchased. This yields a marginal cost of 8.2 Rand.

S7. ESTIMATION RESULTS

S7.1. *Marginal Effects and Price Elasticities*

I average household-level marginal effects separately for various groups (indigent/non-indigent, restricted/non-restricted) to measure any differences in the effects of explanatory variables across these groups. All marginal effects are based on the same set of household-level marginal effects estimated from the entire sample. The results are in Table S-VIII. The interpretation of the marginal effects of variables used to create the groups is as follows. For the indigent group, the marginal effect of the Indigent variable measures the effect of being indigent relative to the counterfactual of not being indigent. For the non-indigent group, it measures the effect of the counterfactual of becoming indigent relative to not being indigent. Table S-IX shows price elasticities by various consumer groups.

TABLE S-VIII

MARGINAL EFFECTS[a]

	Groups				
Variable	All	Indigent	Non-Indigent	Restricted	Non-Restricted
Price	−1.124	−1.035	−1.136	−1.136	−1.121
	(0.003)	(0.013)	(0.002)	(0.007)	(0.003)
Income $\times 10^{-4}$	0.366	0.341	0.370	0.374	0.365
	(0.004)	(0.015)	(0.005)	(0.011)	(0.004)
Avg. max daily temperature (°F)	0.205	0.187	0.207	0.202	0.205
	(0.001)	(0.003)	(0.001)	(0.002)	(0.001)
Number of people on the property	0.055	0.051	0.056	0.055	0.055
	(0.0005)	(0.002)	(0.0005)	(0.001)	(0.001)
Outdoor water usage	0.102	0.092	0.103	0.100	0.102
	(0.001)	(0.002)	(0.001)	(0.001)	(0.001)
Binary variables					
Indigent	0.377	0.340	0.381	0.371	0.378
	(0.001)	(0.004)	(0.001)	(0.003)	(0.001)
Restricted	0.357	0.330	0.360	0.350	0.358
	(0.001)	(0.005)	(0.001)	(0.003)	(0.001)
Sanitation	3.428	3.154	3.464	3.502	3.411
	(0.027)	(0.074)	(0.032)	(0.065)	(0.037)
Washing machine	0.093	0.085	0.094	0.094	0.093
	(0.001)	(0.002)	(0.001)	(0.001)	(0.001)
Bathtub or shower	5.814	5.655	5.834	5.929	5.787
	(0.013)	(0.058)	(0.012)	(0.031)	(0.016)
Completed high school	−0.125	−0.115	−0.127	−0.124	−0.126
	(0.001)	(0.002)	(0.001)	(0.002)	(0.001)
N	10,000	1142	8858	1882	8118

[a]For continuous variables, the marginal effect reflects the impact of a unit increase in the variable on expected consumption (in kl). For categorical variables, it is the impact of an increase by one category (e.g., 0 to 1). For price, all marginal prices in the schedule are increased by 1 Rand. Expected consumption before and after the change is computed at the individual level as described in the Appendix of the paper, and averaged within the different consumer groups in each column. Standard errors are based on 100 bootstrapped samples of the same size as the estimation sample, taken with replacement. Reported standard errors are the standard deviations across these bootstraps.

TABLE S-IX

PRICE ELASTICITIES BY CONSUMER GROUPS[a]

	Consumption Quartile				
	1st (1–6 kl)	2nd (7–10 kl)	3rd (11–17 kl)	4th (18+ kl)	Overall
All	−1.022	−0.997	−0.971	−0.923	−0.976
	(0.010)	(0.009)	(0.010)	(0.008)	(0.004)
Indigent	−0.954	−0.964	−0.879	−0.873	−0.915
	(0.042)	(0.038)	(0.025)	(0.036)	(0.015)
Non-indigent	−1.030	−1.001	−0.984	−0.930	−0.984
	(0.010)	(0.009)	(0.011)	(0.009)	(0.005)
Restricted	−1.049	−1.016	−0.983	−0.935	−0.935
	(0.031)	(0.029)	(0.021)	(0.020)	(0.020)
Non-restricted	−1.017	−0.993	−0.968	−0.920	−0.973
	(0.009)	(0.008)	(0.010)	(0.011)	(0.004)
Sanitation	−1.084	−1.021	−0.986	−0.935	−1.000
	(0.012)	(0.009)	(0.010)	(0.010)	(0.005)
No sanitation	−0.806	−0.789	−0.762	−0.791	−0.793
	(0.008)	(0.011)	(0.016)	(0.014)	(0.006)
Bathtub	−0.838	−0.849	−0.872	−0.839	−0.851
	(0.013)	(0.009)	(0.010)	(0.011)	(0.006)
No bathtub	−1.137	−1.186	−1.186	−1.172	−1.166
	(0.011)	(0.013)	(0.016)	(0.018)	(0.008)
Less than 2 persons on property	−1.095	−1.060	−1.002	−0.907	−1.035
	(0.023)	(0.023)	(0.027)	(0.024)	(0.013)
More than 2 persons on property	−1.005	−0.985	−0.967	−0.925	−0.967
	(0.011)	(0.010)	(0.009)	(0.009)	(0.005)
Below average income	−1.037	−1.030	−0.984	−0.957	−1.004
	(0.010)	(0.012)	(0.010)	(0.013)	(0.006)
Above average income	−0.983	−0.938	−0.954	−0.886	−0.933
	(0.019)	(0.015)	(0.015)	(0.013)	(0.007)
Completed high school	−1.0208	−0.9922	−0.9598	−0.9129	−0.968
	(0.012)	(0.010)	(0.011)	(0.011)	(0.005)
No completed high school	−1.0259	−1.007	−0.9984	−0.9513	−0.996
	(0.018)	(0.015)	(0.018)	(0.015)	(0.007)
Washing machine	−0.995	−0.957	−0.948	−0.911	−0.947
	(0.011)	(0.010)	(0.010)	(0.010)	(0.005)
No washing machine	−1.050	−1.054	−1.010	−0.951	−1.020
	(0.013)	(0.014)	(0.015)	(0.015)	(0.008)

[a]Price elasticities reflect the percentage change in consumption in response to a 1 percent change in all marginal prices (0 prices are increased to 1 Rand). Elasticities are based on expected consumption before and after the change, computed at the household level as described in the Appendix of the paper, and averaged within the different consumer groups and consumption quartiles. Standard errors are based on 100 bootstrapped samples of the same size as the estimation sample, taken with replacement. Reported standard errors are the standard deviations across these bootstraps.

S7.2. *Model Performance*

Table S-X investigates the out-of-sample performance of the model. I use the estimated parameters to predict consumption for the 53,178 monthly observations that were not used in the estimation.

TABLE S-X

MODEL PERFORMANCE: OUT OF SAMPLE[a]

	Actual Mean	Predicted Mean	Average Error	N
All	13.395	13.063	−0.332	53,178
Indigent	13.206	13.369	0.163	6392
Non-indigent	13.421	13.021	−0.400	46,786
Restricted	14.990	13.687	−1.303	10,349
Non-restricted	13.010	12.912	−0.098	42,829

[a] Entries in the 'Actual' and 'Predicted' columns are average household consumption levels in kl. The Predicted mean column gives the average expected consumption predicted by the model with the estimated parameter values in the Appendix of the paper. Expected consumption is computed at the individual level as described in the Appendix of the paper. Average error is the difference between the actual and predicted means. Values in the table are for the 53,178 monthly observations that were not used in estimating the parameters.

S8. COUNTERFACTUAL ANALYSIS WITHOUT FREE WATER

TABLE S-XI

COUNTERFACTUAL ANALYSIS WITHOUT FREE WATER: HOUSEHOLD CONSUMPTION AND EXPENDITURE CHANGES, ALTERNATIVE EFFECTIVE PRICES[a]

	All	Indigent	Non-Indigent	Restricted	Non-Restricted
Consumption (kl/month)					
With free water	13.307	13.408	13.293	13.826	13.183
Without free water,					
30% higher effective prices	12.391	12.220	12.414	12.814	12.291
Change (%)	−6.880	−8.166	−6.708	−3.702	−7.632
Without free water,					
60% higher effective prices	9.939	9.318	10.021	10.242	9.868
Change (%)	−25.307	−29.974	−24.691	−23.030	−25.841
Without free water,					
90% higher effective prices	3.849	2.778	3.989	2.901	4.075
Change (%)	−71.074	−79.123	−70.022	−78.199	−69.376
Expenditures (Rand/month)					
With free water	77.337	80.140	76.971	85.033	75.506
Without free water,					
30% higher effective prices	147.693	152.527	147.062	159.801	144.812
Change (%)	90.973	97.224	90.157	106.629	87.248
Without free water,					
60% higher effective prices	131.264	129.694	131.468	142.271	128.644
Change (%)	69.730	67.700	69.994	83.962	66.342
Without free water,					
90% higher effective prices	67.685	62.671	68.339	64.277	68.496
Change (%)	−12.480	−18.964	−11.635	−16.887	−11.432

[a] Values reported are the model predicted values using either the actual water tariffs ("With free water"), or the counterfactual tariffs where 0 prices were replaced with 30, 60, and 90 percent higher prices than the actual effective price ("Without free water"). Expected consumption is computed at the individual level as described in the Appendix of the paper, and averaged within the different consumer groups in each column. Expenditure is average household water spending (in 2008 Rand). $N = 7309$ (observations after the 2007 policy change are excluded from both the actual and the counterfactual computations).

S9. OPTIMAL TARIFFS

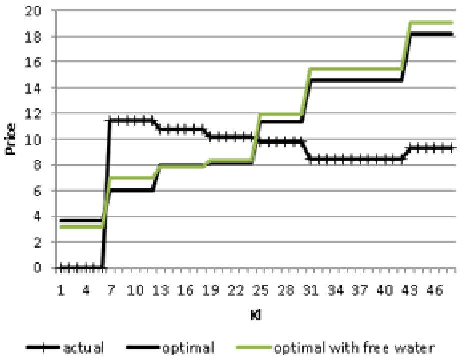

FIGURE S12.—Optimal and actual 2006/2007 tariff schedules, low marginal cost. *Notes*: The figure shows the actual 2006/2007 tariff and the corresponding optimal tariffs with and without 6 kl free water for indigent households. The marginal cost is set to 4 Rand. The "optimal with free water" schedule shown is for non-indigent households.

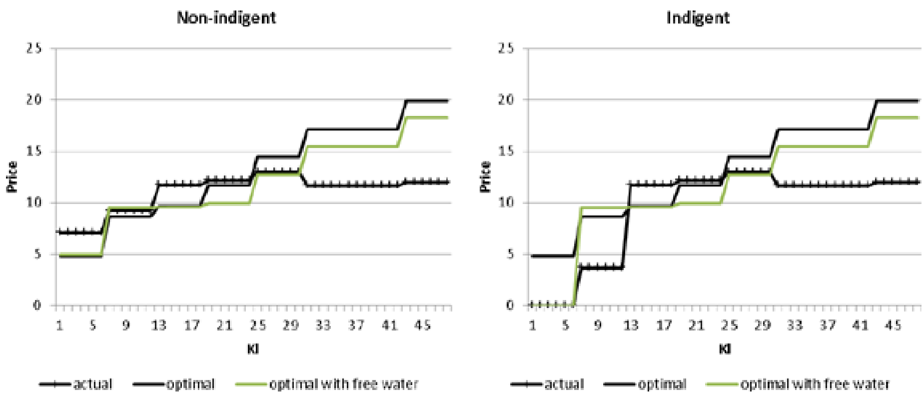

FIGURE S13.—Optimal and actual 2008/2009 tariff schedules, low marginal cost. *Notes*: The figure shows the actual 2008/2009 tariff and the corresponding optimal tariffs with and without 6 kl free water for indigent households. The marginal cost is set to 4 Rand.

TABLE S-XII

COMPENSATING VARIATION UNDER THE OPTIMAL TARIFFS (MEAN/MEDIAN)[a]

	2006/2007 Optimal Tariff			2008/2009 Optimal Tariff		
	Without Free Water	Wih Free Water	*N*	Without Free Water	With Free Water	*N*
Panel A: High marginal cost						
Compensating variation						
All	−3.98/−6.59	−3.61/−5.00	8385	−1.96/−12.54	−1.04/−7.51	5660
Indigent	−3.75/−6.27	−25.66/−28.48	1021	61.59/61.79	37.35/37.61	877
Non-indigent	−4.01/−6.62	−0.55/−3.43	7364	−13.62/−12.79	−8.09/−8.07	4783
Consumption						
Consumption (kl)	15.87/16.57	16.04/17.02	8385	13.36/14.11	12.85/13.87	8385
Low consumption (%)	19.11	15.56	–	41.27	41.48	–
Medium consumption (%)	49.48	49.83	–	58.66	58.52	–
High consumption (%)	31.41	34.61	–	0.07	0.00	–
Panel B: Low marginal cost						
Compensating variation						
All	−18.51/−21.78	−18.03/−20.51	8385	−8.80/−19.20	−7.88/−13.15	5660
Indigent	−18.35/−21.29	−34.70/−37.92	1021	54.87/55.55	30.53/31.05	877
Non-indigent	−18.54/−21.29	−15.72/ −19.29	7364	−20.48/−20.22	−14.92/−14.18	4783
Consumption						
Consumption (kl)	16.81/17.63	16.75/17.74	8385	14.19/14.93	13.90/14.98	8385
Low consumption (%)	11.87	11.56	–	38.60	38.22	–
Medium consumption (%)	44.00	45.27	–	61.13	56.57	–
High consumption (%)	44.13	43.17	–	0.27	5.21	–
Panel C: Actual consumption						
Consumption (kl)	13.36/14.49		8385	12.76/12.60		8385
Low consumption (%)	55.60		–	65.44		–
Medium consumption (%)	21.13		–	17.91		–
High consumption (%)	23.27		–	16.75		–

[a]The table reports the compensating variation corresponding to the optimal tariffs. If the provider switched from the actual (2006/2007 or 2008/2009) tariff to the optimal tariff, this is the change in income that would leave a consumer as well off as he was before the switch. Negative numbers indicate an increase in consumer utility from the switch. In each cell, the first entry is the mean, the second entry is the median compensating variation. All entries are in 2008 Rand. Each row in the table presents the fraction of consumers consuming Low (0–12 kl), Medium (12–18 kl), or High (above 18 kl) quantities of water under the tariff schedule indicated in the first column.

TABLE S-XIII

DISTRIBUTION OF CONSUMPTION UNDER ACTUAL AND OPTIMAL TARIFF SCHEDULES[a]

	Consumption (kl)		Consumption Distribution (Percent)			
Tariff Schedule	Mean	Median	Low	Medium	High	Total
Panel A: actual						
2006/2007	13.36	14.49	55.60	21.13	23.27	100
2008/2009	12.76	12.6	65.44	17.81	16.75	100
Panel B: optimal (high marginal cost)						
2006/2007 optimal	15.87	16.57	19.11	49.48	31.41	100
2006/2007 optimal with free water	16.04	17.02	15.56	49.83	34.61	100
2008/2009 optimal	13.36	14.11	41.27	58.66	0.07	100
2008/2009 optimal with free water	12.85	13.87	41.48	58.52	0.00	100
Panel C: optimal (low marginal cost)						
2006/2007 optimal	16.81	17.63	11.87	44.00	44.13	100
2006/2007 optimal with free water	16.75	17.74	11.56	45.27	43.17	100
2008/2009 optimal	14.19	14.93	38.60	61.13	0.27	100
2008/2009 optimal with free water	13.90	14.98	38.22	56.57	5.21	100

[a]Each row in the table presents the fraction of consumers consuming Low (0–12 kl), Medium (12–18 kl), or High (above 18 kl) quantities of water under the tariff schedule indicated in the first column.

TABLE S-XIV

EXPENDITURE UNDER THE OPTIMAL TARIFFS[a]

	2006/2007	2006/2007 Optimal Tariff			2008/2009	2008/2009 Optimal Tariff		
	Actual	Without Free Water	Wih Free Water	N	Actual	Without Free Water	With free Water	N
Panel A: High marginal cost								
All	86.13	103.06	105.06	8385	93.34	101.43	97.16	5660
Indigent	81.85	102.49	82.37	1021	48.45	100.31	70.67	877
Non-indigent	86.76	103.14	108.37	7364	101.57	101.63	102.02	4783
Restricted	101.41	106.13	106.47	2011	108.94	109.24	103.06	1208
Non-restricted	81.35	102.09	104.62	6374	89.11	99.31	95.56	4452
Panel B: Low marginal cost								
All	86.13	96.54	96.53	8385	93.34	102.73	100.95	5660
Indigent	81.85	96.01	79.33	1021	48.45	101.39	74.39	877
Non-indigent	86.76	96.62	98.92	7364	101.57	102.98	105.83	4783
Restricted	101.41	99.51	98.12	2011	108.94	109.34	105.94	1208
Non-restricted	81.35	95.61	96.03	6374	89.11	100.94	99.60	4452

[a]The table reports average expenditures under the optimal tariffs discussed in Section 7.3. It also reports the observed average expenditure under the actual 2006/2007 and 2008/2009 tariffs for comparison. All entries are in 2008 Rand.

S10. SEPARATE TARIFFS FOR INDIGENT AND NON-INDIGENT HOUSEHOLDS

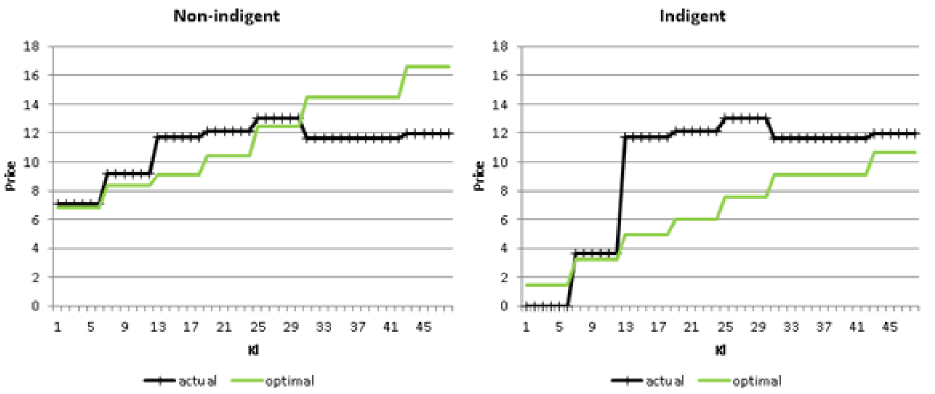

FIGURE S14.—Separate optimal and actual 2008/2009 tariff schedules for non-indigent and indigent households, low marginal cost. *Notes*: The figure shows the optimal and actual 2008/2009 tariff when the social planner sets the tariff for the non-indigent group only (left-hand side) or the indigent group only (right-hand side). Optimal tariffs maximize welfare subject to a profit neutrality constraint for the given group only. The marginal cost is set to 4 Rand.

TABLE S-XV

COMPENSATING VARIATION AND CONSUMPTION UNDER INDIGENT-ONLY AND NON-INDIGENT-ONLY OPTIMAL TARIFFS[a]

	Compensating Variation		Consumption (kl)		
	Mean	Median	Mean	Median	*N*
Panel A: High marginal cost					
Indigent	−2.66	−7.14	16.63	18.00	877
Non-indigent	−2.74	−2.00	13.72	14.75	4783
Panel B: Low marginal cost					
Indigent	−17.64	−22.39	18.42	19.04	877
Non-indigent	−11.79	−11.91	14.65	15.60	4783

[a]The table reports the compensating variation corresponding to the indigent-only and non-indigent-only optimal tariffs, as well as the consumption resulting from these tariffs. If the provider switched from the actual (2008/2009) tariff to the optimal tariff for the given group, the compensating variation is the change in income that would leave a consumer in this group as well off as he was before the switch. Negative numbers indicate an increase in consumer utility from the switch.

TABLE S-XVI

EXPENDITURE UNDER INDIGENT-ONLY AND NON-INDIGENT-ONLY OPTIMAL TARIFFS[a]

	2008/2009 Actual Tariff	Optimal Tariff	N
Panel A: High marginal cost			
Indigent	48.45	64.61	877
Non-indigent	101.57	116.05	4783
Panel B: Low marginal cost			
Indigent	48.45	61.33	877
Non-indigent	101.57	115.59	4783

[a]The table reports average expenditures under the optimal tariffs discussed in Section 7.5. It also reports the observed average expenditure under the actual 2008/2009 tariffs for comparison. All entries are in 2008 Rand.

S11. OPTIMAL TARIFFS UNDER REVENUE AND CAPACITY CONSTRAINTS

TABLE S-XVII

COMPENSATING VARIATION UNDER THE OPTIMAL TARIFFS WITH CAPACITY AND REVENUE NEUTRALITY CONSTRAINTS (MEAN/MEDIAN)[a]

	Optimal Tariff		
	Without Free Water	With Free Water	N
All	−0.40/−11.88	−0.94/−7.41	5660
Indigent	63.52/63.14	37.69/38.01	877
Non-indigent	−12.05/−12.04	−8.03/−8.03	4783
Restricted	7.07/−11.80	3.60/−7.14	1208
Non-restricted	−2.43/−11.90	−2.18/−7.50	4452

[a]The table reports the compensating variation corresponding to the optimal tariffs discussed in Section 7.6 of the paper. If the provider switched from the actual tariff to the optimal tariff, this is the change in income that would leave a consumer as well off as he was before the switch. Negative numbers indicate an increase in consumer utility from the switch. In each cell, the first entry is the mean, the second entry is the median compensating variation. All entries are in 2008 Rand.

TABLE S-XVIII

CONSUMPTION DISTRIBUTION UNDER THE OPTIMAL TARIFFS WITH CAPACITY AND REVENUE NEUTRALITY CONSTRAINTS[a]

	Consumption (kl)		Consumption Distribution (Percent)			
Tariff Schedule	Mean	Median	Low	Medium	High	Total
Actual	12.76	12.6	65.44	17.81	16.75	100
Optimal	12.76	13.00	41.41	58.59	0	100
Optimal with free water	12.76	13.74	41.41	58.59	0	100

[a]The table describes consumption under the actual and optimal tariffs. For the distribution of consumption, Low, Medium, and High refer to the fraction of consumers consuming, respectively, 0–12 kl, 12–18 kl, or above 18 kl.

TABLE S-XIX

EXPENDITURE UNDER THE OPTIMAL TARIFFS WITH CAPACITY AND REVENUE NEUTRALITY CONSTRAINTS[a]

	2008/2009	Optimal Tariff		
	Actual Tariff	Without Free Water	Wih Free Water	N
All	93.34	96.38	96.32	5660
Indigent	48.45	95.99	70.15	877
Non-indigent	101.57	96.45	101.12	4783
Restricted	108.94	103.57	102.24	1208
Non-restricted	89.11	94.42	94.72	4452

[a]The table reports average expenditures under the optimal tariffs discussed in Section 7.6. It also reports the observed average expenditure under the actual 2008/2009 tariffs for comparison. All entries are in 2008 Rand.

S12. ROBUSTNESS TO ALTERNATIVE INCOME MEASURES

To investigate the robustness of the model estimates to the income measure used, I also estimated the model using only sampled households with both reported and estimated income. Specifically, from my random 10,000 estimation sample, I pulled households with observed income data ($N = 5731$). Next, I estimated the model for these 5731 household-month observations separately, using either estimated or observed income. The resulting parameter vectors from the likelihood model are in Table S-XXI. Next, I computed the predicted consumption and average model error for these two cases separately, and I also simulated the average price elasticity in both cases. These are included in Table S-XX, and the numbers are consistent with those used in the main text. This is not too surprising since the estimated coefficient on the income variable is small in each case, and household income (even reported income) has a relatively small variance in this sample.

TABLE S-XX

MODEL PERFORMANCE AND PRICE ELASTICITY ESTIMATES WITH ALTERNATIVE INCOME MEASURES[a]

	Observed Income	Estimated Income	Results From the Main Text
Actual mean consumption	13.276	13.276	13.353
Predicted mean consumption	13.033	13.012	13.071
Average error	−0.243	−0.264	−0.282
Average price elasticity	−0.979	−0.981	−0.976
N	5731	5731	10,000

[a]The table reports model performance measures and estimated average price elasticities using alternative samples and income measures. The first two columns show ML estimates using only the 576 households whose reported income is non-missing in the survey. The first column uses reported income, while the second column uses estimated income for these households in the estimation. The last column shows the corresponding values from the main text.

TABLE S-XXI

PARAMETER ESTIMATES WITH ALTERNATIVE INCOME MEASURES[a]

	Observed Income		Estimated Income		Results From the Main Text	
Variables	Parameter	SE	Parameter	SE	Parameter	SE
Constant	2.134	0.028	2.115	0.026	2.111	0.011
Indigent	0.357	0.175	0.366	1.917	0.364	0.142
Restricted	0.341	0.024	0.343	0.071	0.344	0.033
Sanitation	4.793	0.046	4.789	0.100	4.787	0.038
Average max daily temperature (°F)	0.197	0.000	0.197	0.001	0.197	0.000
Washing machine	0.090	0.039	0.091	0.054	0.091	0.014
Number of people on the property	0.054	0.007	0.053	0.021	0.053	0.003
Outdoor water usage	0.099	0.009	0.098	0.053	0.097	0.007
Bathtub or shower	6.255	0.031	6.317	0.034	6.261	0.013
Completed high school	−0.117	0.021	−0.121	0.079	−0.120	0.044
Price	−1.140	0.001	−1.139	0.014	−1.139	0.002
Income	0.366×10^{-4}	0.060×10^{-4}	0.347×10^{-4}	0.057×10^{-4}	0.358×10^{-4}	0.046×10^{-4}
σ_η	0.005	0.017	0.005	0.006	0.005	0.006
σ_ϵ	9.167	0.220	9.202	0.220	9.233	0.163
N	5731		5731		10,000	

[a]The table presents parameter estimates from the maximum likelihood model using alternative samples and income measures. The first two sets of parameters were estimated using only the 576 households whose reported income is non-missing in the survey. The first two columns use reported income, while the next two columns use estimated income for these households in the estimation. The last set of parameter estimates are those reported in the main text.

S13. ROBUSTNESS TO CONTROLLING FOR FIRST TARIFF QUARTER

Some of the graphs in Section S4 suggested that consumers' response to tariff changes may be different in the first tariff quarter. In this section, I investigate whether controlling for this affects the estimates reported in the paper. Specifically, I repeat the estimation including in the vector **Z** a dummy variable equal to 1 for observations in the first quarter of each tariff year (July–September) and 0 otherwise. This allows for any differences in consumer behavior in this quarter.

The resulting parameter estimates are in Table S-XXII. For comparison, the table also reports the estimates from the main text. As can be seen, the coefficient on the newly included First Quarter dummy is not statistically significant. To investigate the performance of the model, Table S-XXIII compares actual and predicted mean consumption, again listing the corresponding values from the main text for comparison. As can be seen, although the average performance of the model improved somewhat, it is now less accurate in predicting consumption *both* in the first quarter and in other tariff quarters. Average performance only improved because the negative average error in predicting first

TABLE S-XXII

PARAMETER ESTIMATES CONTROLLING FOR FIRST TARIFF QUARTER[a]

	With First Quarter Dummy		Results From the Main Text	
Variables	Parameter	SE	Parameter	SE
Constant	2.999	0.089	2.111	0.011
Indigent	0.269	0.073	0.364	0.142
Restricted	0.194	0.089	0.344	0.033
Sanitation	5.250	0.061	4.787	0.038
Average max daily temperature (°F)	0.198	0.002	0.197	0.000
Washing machine	0.069	0.051	0.091	0.014
Number of people on the property	0.042	0.006	0.053	0.003
Outdoor water usage	0.112	0.024	0.097	0.007
Bathtub or shower	6.512	0.057	6.261	0.013
Completed high school	−0.138	0.101	−0.120	0.044
First quarter	−0.190	0.131	–	–
Price	−1.259	0.024	−1.139	0.002
Income	0.308×10^{-4}	0.043×10^{-4}	0.358×10^{-4}	0.046×10^{-4}
σ_η	0.005	0.008	0.005	0.006
σ_ϵ	9.281	0.161	9.233	0.163
N	10,000		10,000	

[a]The table presents parameter estimates from the maximum likelihood model including an indicator for observations from the first tariff quarter (July–September). For comparison, the table also shows the parameter estimates reported in the main text.

TABLE S-XXIII

MODEL PERFORMANCE CONTROLLING FOR FIRST TARIFF QUARTER[a]

	With First Quarter Dummy	Results From the Main Text
All quarters		
Actual mean consumption	13.353	13.353
Predicted mean consumption	13.201	13.071
Average error	−0.152	−0.282
N	10,000	10,000
Quarter 1		
Actual mean consumption	13.180	13.180
Predicted mean consumption	12.266	12.311
Average error	−0.914	−0.869
N	2471	2471
Quarters 2–4		
Actual mean consumption	13.410	13.410
Predicted mean consumption	13.508	13.321
Average error	0.098	−0.089
N	7529	7529

[a]Entries in the 'Actual' and 'Predicted' rows are average household consumption levels in kl. Predicted mean is the average expected consumption predicted by the model with the estimated parameter values. Expected consumption is computed at the individual level as described in the Appendix of the paper. Average error is the difference between the actual and predicted means. The table presents these values for all tariff quarters as well as separately for the first and other tariff quarters. The first column uses the new parameter estimates including the first quarter dummy; the second column uses the parameter estimates from the paper for comparison.

quarter consumption is now partially offset by a positive average error in predicting consumption in other quarters.

Overall, these results do not suggest that differences in consumer behavior in the first tariff quarter are statistically significant, nor that controlling for them necessarily improves the fit of the model.

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