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The elasticity of commercial water demand in Nairobi, Kenya

An Instrumental Variable Estimation

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The coping costs of dealing with unreliable water supply in the Nairobi commercial sector

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Abstract

We investigate the price responsiveness of commercial and industrial water users in Nairobi, Kenya using billing data from 32,793 commercial and industrial customers over five years that includes 663,000 billing records with usable, metered water use data. We examine water demand before and after a relatively substantial tariff increase in 2015 that collapsed the increasing block tariff from four blocks to three and created a new zero-cost ”lifeline” block of seven cubic meters. Rather than estimate an instrumental variables approach, we use a simple price specification that we believe fits the available evidence on price perception from the household demand literature: lagged average total price. Pooling all data, we find inelastic demand: a 10% increase in average total price is associated with a 1.1% reduction in monthly water use. Firms that have a lower mean monthly water use are more price responsive than firms with moderate water use. We find no price effect among the largest water users. Finally, we estimate separate demand models for various types of businesses, finding inelastic demand in six of seven categories (construction, garages, industrial users, markets/retail, and small office buildings). Large office buildings are not price responsive, and we find wrong-signed price elasticities for restaurants.

Keywords: Water Demand, Commercial firms, Water Elasticity, Kenya

JEL Codes: Q25, Q31, Q51, L20

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Introduction

The majority of studies in water resource economics have focused either on the behavior of households or farmers growing irrigated crops. There is less information on demand elasticities, coping behaviors (in response to unreliable and low-quality supply) or productivity effects of unreliable water to industrial and commercial enterprises in developing countries. Commercial firms typically constitute a relatively small share of water users and obtaining data on the uses of water observed in commercial processes is difficult (Renzetti 2015) . In many cities, though, the commercial and industrial water use can be substantial. For example, although non-residential water customers are less than 5 percent of the customer base in the Nairobi City Water and Sewerage Company (NCWSC) billing system, they account for 35 per cent of overall water use (Fuente et al. 2016). In this paper we investigate the price responsiveness of commercial firms such as shops, restaurants, small businesses and industrial users that are connected to the piped network. Research that allows for better predictions of these commercial customers' behavior is important for policy analysis of increases in tariffs towards cost-recovery levels or investments to improve supply. Sector-specific elasticities might be useful for utilities' demand projections if staff had estimates from elsewhere in goverment about projected growth in different types of businesses.

Although a large number of studies have examined the price elasticities of residential and agricultural water users (Sebri 2014; Dharmaratna and Parasnis 2010; Nauges and Whittington 2010; Reynaud 2003), relatively few studies have examined industrial and commercial water demand (Flyr et al. 2019; Angulo et al. 2014; Moeltner and Stoddard 2004, Vasquez-Lavin et al 2020). Angulo et al., (2014) looked at the role of water in the production process of hotels and restaurants and the possible implications of water demand management policy for this sector in the city of Zaragoza (Spain)(Angulo et al. 2014). Based on trans-log cost function, they estimated the shadow price of water in the short run and long-run perspective. The results obtained show that water provides the sector firms returns that are on average higher than its price. Moeltner and Stoddard (2004) in a study of water consumption among the non-residential customers in Reno, Nevada (USA) modeled demand using a random effects specification and estimate elasticities ranging from –0.045 in the eating and drinking sector to –0.141 in the amusement and recreation sector(Moeltner and Stoddard 2004). More recently, Flyr et al., (2019) estimated separate elasticities for different categories of commercial customers in Fort Collins

(USA), finding that some categories like offices, car washes, and retail stores were much more price sensitive than medical facilities and eating/drinking establishments(Flyr et al. 2019). In developed countries within the global south, Vasquez-Lavin et al (2020) use the production function approach to estimate the economic value of water and price elasticities of water in Chile's manufacturing industry (Vásquez-Lavín et al. 2020). To our knowledge, Hussain, Thrikawala & Barker (2002)'s study in Sri Lanka and Yudhistra et al (2020)'s study in Indonesia are the only commercial water price elasticity studies conducted in low income countries (Yudhistira, Sastiono, and Meliyawati 2020; Hussain, Thrikawala, and Barker 2002) . The authors estimated separate water-demand functions for each of the major sectors using monthly aggregated panel data and found that price has a significant effect on water demand, and this effect is much higher for the industrial sector than for the residential and commercial sectors(Hussain, Thrikawala, and Barker 2002).

In this paper we estimate the price elasticity of 11,375 commercial and industrial customers in Nairobi over five years using a total of 698,807 billing records with usable, metered water use data. We examine the effect of a relatively substantial tariff increase in 2015 that collapsed the increasing block tariff from four blocks to three and creating a new zero-cost ”lifeline” block of seven cubic meters. In this draft, we use a simple price specification that uses the average total price from last month's bill rather than an instrumental variables approach using marginal prices or a full discrete-continuous model as in Hewitt and Hanemann (1995). We suspect most customers are unaware of the volumetric tariff scheme; the choice of block is therefore not endogenous. We prefer average total price to average volumetric price because we believe customers would be more likely to use a decision heuristic that takes the total bill paid and divide by the total units of consumption. Naive models that use lagged marginal price or lagged average volumetric price show statistically-significant price elasticities with the wrong sign. Using lagged average total price, however, we find that commercial demand is quite inelastic in Nairobi.

Pooling all data, we find that a 10% increase in average total price is associated with a 1.1% reduction in monthly water use. Partitioning firms by the size of their mean water use, we find more price responsiveness among ”small” firms (mean water use < $10m^3$) than ”medium” firms (10 – 1000m3). ”Large” firms using more than 1000 cubic meters per month on average are not price responsive. Finally, we estimate separate demand models for various types of businesses, though only 10% of firms in our data have been classified thus far. We find inelastic demand in six of the seven categories: construction, garages, industrial users, markets/retail, and small office buildings. We find no statistically significant impact of the price change for large office buildings, and our price measure puzzlingly has the wrong sign and is statistically significant for restaurants.

Data and study setting

We used an 8-year panel (1st January 2012- 31st July 2020) of monthly billing data of commercial users in Nairobi obtained from city's water distributor, Nairobi City Water and Sewerage Company (NCWSC) . After removing uncategorised and non-commercial customers' accounts, we had 698,807 billing records for our analysis. The dataset variables include customer classification, geographical location of the customer, monthly billed consumption and volume, customer identification number (ID), meter rent amount, billing period and bill tarriff. Most of the customers in our sample receive both water and sewerage services, though NCWSC also has tariff schedules for customers who receive only water or only sewer services.

We merged in information on the categories of commercial customer as classified by NWSC. Unfortunately, we could match commercial classifications for only 16% of customer accounts. (NWSC is continuing to classify customer accounts and we hope to be able to classify more). We cleaned data by removing negative water volumes and removing firms that had less than five valid water use observations among the 60 billing periods. We also coded monthly water use observations to missing if they were over five standard deviations higher than the mean monthly water use for that firm. Detailed firm characteristics such as number of employees and revenues are unfortunately unavailable in the billing records, though this is a common data constraint in existing studies.

The tariffs prevailing at the beginning of our dataset in 2012 had been in place since 2009. Charges for water service were comprised of a fixed "meter rent" charge (typically Ksh 100 for a 3/4" connection) and an increasing block volumetric charge with four blocks (Figure 1). Sewerage charges were volumetric and based on water volumes consumed and water tariffs: the sewerage bill was 75% of the total volumetric bill for water services. Tariffs were revised in July 2015, taking effect for the bills sent in October 2015. During the 2015 tariff revision, fixed charges (meter rents) were changed for connections larger than 1" (some increasing and some decreasing), and the volumetric water tariff was simplified to three blocks (Figure 1). Consumption in the first block (up to 6 m3) was charged a flat rate of Ksh 204 with no volumetric component. The price in new second block (6 - 10 m3) was substantially higher than corresponding volumetric charges for the two consolidated blocks under the old tariff. The location of the top block remained at 10 m3, but the price increased from Ksh 53.8 to Ksh 64 per cubic meter. Sewerage charges remained 75% of the total volumetric water bill.

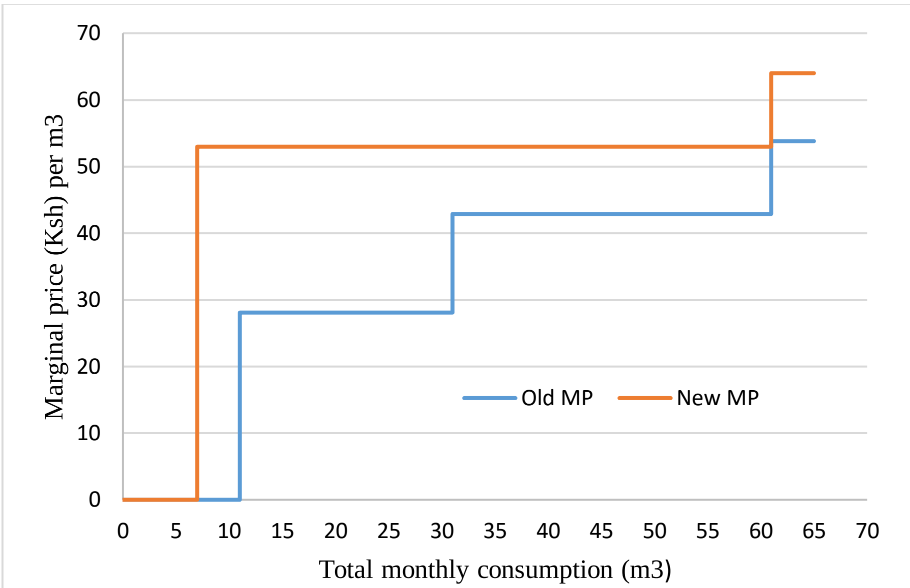
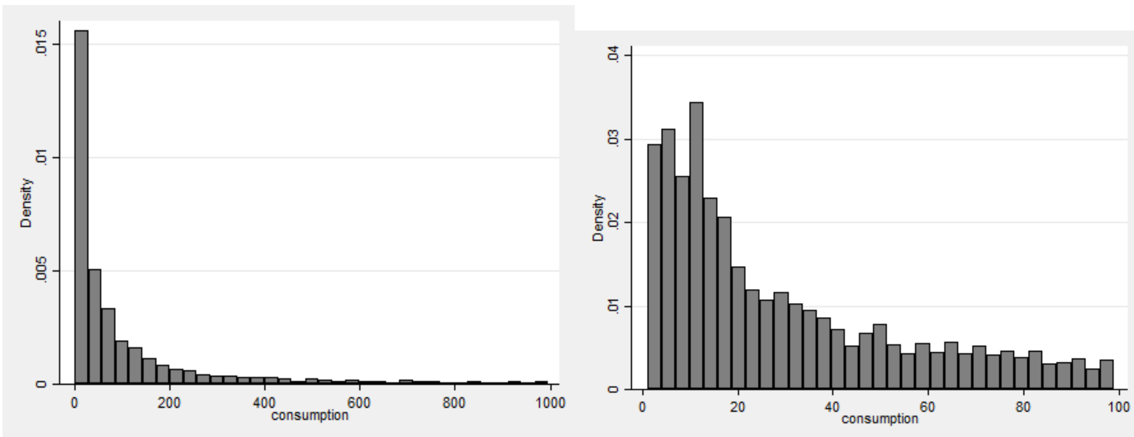


Figure 1. Old and revised increasing block tariff

Figure 2. Distribution of commercial water use in one representative month (October 2014): full distribution (left) and among accounts using less than 100 m^3 (right).



N=9,323. Excludes 640 observations >1000m3. N=6,753 firms

To test for price responsiveness of different type of business to water prices, we categorized the firms further to seven categories as listed Table 1. As shown by the descriptive statistics, industrial facilities and large office blocks were the largest consumers while auto garage, construction sites and retail stores had the least water consumption. We also compared mean water use in each category in the 12 months before and after the tariff went into effect. We find that mean monthly water use declined in the 12 months after the price change in four of the sectors but increased in three of the sectors, though none of the differences are statistically significant. The final row of Table 1 present similar statistics for the entire commercial water use dataset of 32,793 firms. Overall, mean monthly water use declined by 5.9 cubic meters, though the difference is again not statistically significant.

Finally, monthly climate data from NASA's open data portal[1] was matched to the water consumption data.. Even though Nairobi is within the tropical equator region and most

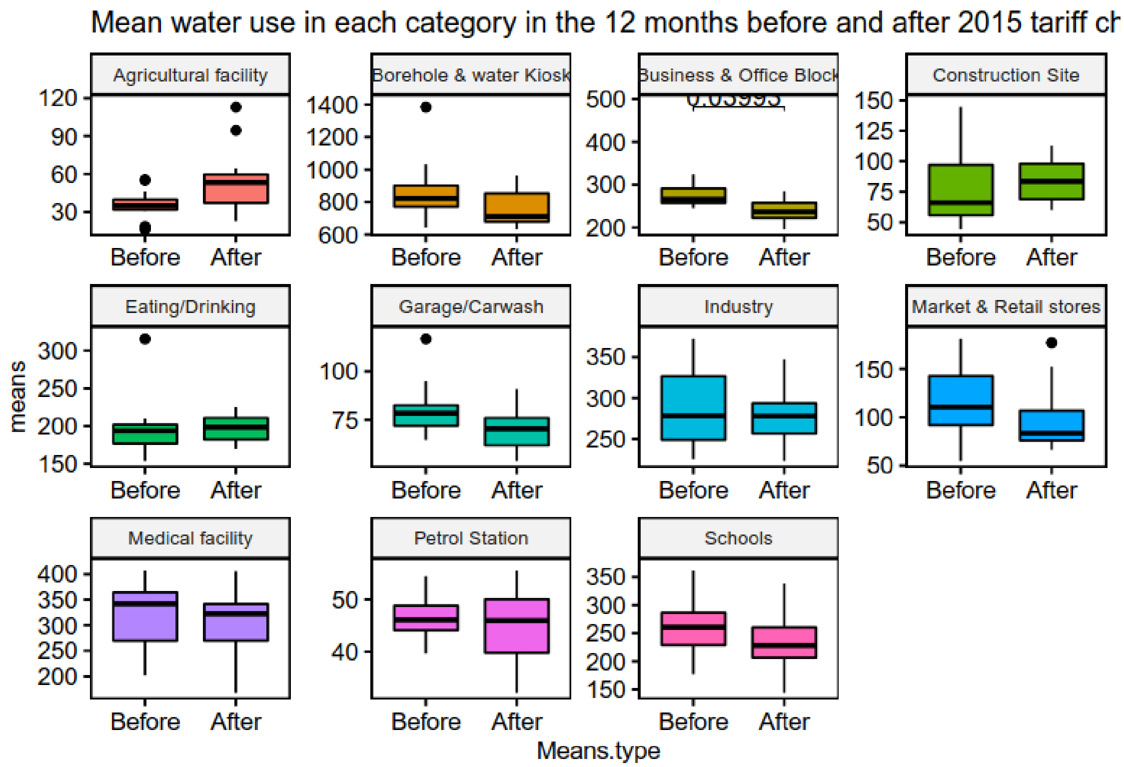
[1] Data was downloaded from https://power.larc.nasa.gov/ via API using R software

commercial businesses will have minimal outdoor water use, we test whether seasonal rains and temperature have an impact on consumed water. Due to minimal variation between the maximum and miminum daily temperature, average daily temperature and daily precipitation were used to construct monthly averages for the study period.

Table 1: Commercial water user's classification and descriptive statistics in m^3 per category from 2012 - 2017

Monthly water consumption (m^3)							
Firm Category	**Category description**	**Number of firms**	**Non-zero billing records**	**Mean**	**Std. Dev**	**Max**	**Diff. in means (se) before and after price change[a]**
Construction	Construction sites	282	3,849	138	150	426	2.25 (8.59)
Industrial facilities	Factory, industrial facilities, workshop	1,396	44,623	503	2914	65,570	27.60 (41.6)
Garage/Carwash	Auto repair and car washes	324	10,984	102	290	4790	-3.38 (7.77)
Large office	Office building block (>20 offices)	814	28,241	417	735	10,335	-5.91 (12.28)
Small office	Office building block (<=20 offices)	1,135	40,135	128	344	6,763	-11.74 (4.87)
Market and retail stores	Supermarkets, open/common markets, shops and small kiosks	445	14,048	76	179	3,245	1.10 (4.46)
Eating/Drinking	Restaurants, hotels, bar, clubs and other catering businesses	685	20,779	332	902	14,639	-29.17 (17.38)
All records	All, including unclassified	32,793	663,540	233	3,317	389,900	-5.86 (13.73)

Notes: [a] Difference in mean 12 billing months after October 2015 minus mean in 12 billing months prior. Unpaired two-tailed t-test, * 10%, ** 5%,***1%



Since the above plots seem sqeezed, I plotted these individual plots for visibility, we can drop them later

Figure 3. Mean water use box plots, by category

Methods

We use a model of commercial water demand following Moeltner & Stoddard (2004) who use a panel data model that builds on the monthly observations of water uses and marginal prices for individual customers over a period of years(Moeltner and Stoddard 2004). However, there is an ongoing debate over the appropriate price term to use in the demand function. That is whether to use marginal or average price, or both prices (Flyr et al. 2019). Both Moeltner & Stoddard (2004) and Flyr et al., (2019) provide a discussion on the test to determine which price term is appropriate and using Shin (1985) test, they find that firms respond to one-period lagged average price (Shin 1985).

There is a well-known econometric identification challenge associated with water billing data where increasing-block tariffs are used: price (block) and water consumed are endogenously determined. Rather than use an instrumental variables approach, in our first model, we simply use lagged prices in this draft because we suspect few customers are aware of the block price structure such that the choice of block is unlikely to be endogenous. We report results from naive tests using lagged (last month's) marginal price from the tariff structure and lagged average volumetric price. We believe lagged average volumetric price, while requiring less information than marginal price, is naive because it still requires the customer to separate the fixed from volumetric components of the bill. We think a decision heuristic where the customer responds to changes in the total bill divided by total use (average total price) is more likely. For firm i, the natural log in water use W in month t is modeled as;

$$ln\, W_{it} = \beta_c C_t + \beta_p lnP_{it-1} + YEAR + \varepsilon_{it} \dots\dots\dots\dots\dots\dots\dots\dots. (1)$$

C_t is climate/weather (precipitation and daily average temperature) and P_{it-1} is the lagged price measure (marginal, average volumetric, average total) of water associated with firm *i* in month t. We include year fixed effects to pick up overall time trends in water consumption. We estimate a panel regression (xtreg) with fixed effects in Stata 15.

In our second model, we use Shin's (1985) price perception model to test whether individual firms react to average or marginal price as employed by previous water demand studies (Flyr et al. 2019; Kavezeri-Karuaihe et al. 2005; Nieswiadomy 1992). Commercial water consumption was modelled a function of perceived price of water, P*. The perceived price, P*, is then constructed as a function of the marginal price (MP), the average price (AP), and a price perception parameter k as follows:

$$P_t^* = MP_t \left(\frac{AP_t}{MP_t}\right)^k \dots\dots\dots\dots\dots\dots\dots\dots\dots\dots. (2)$$

Equation two can be transformed to a log – linear equation as below.

$$lnP_t^* = (1-k)lnMP_t + klnAP_t \dots\dots\dots\dots. (3)$$

The price ratio computed as the ratio, $\frac{AP_t}{MP_t}$ is designed to capture the effect of the difference variable on price perception, and the price perception parameter k in equation (2) is expected to be non-negative (Kavezeri-Karuaihe et al. 2005; Shin 1985). It is for this reason that the difference variable does not enter the Shin demand model directly; rather it is captured through the price ratio (Kavezeri-Karuaihe et al. 2005; Nieswiadomy 1992; Shin 1985).

If the consumer responds only to MP_t, then k = 0. If the consumer responds only to AP_t, then k = 1. If the consumer's perceived price lies between APt, and MPt, then 0 < k < 1. If k >1 then consumers respond to a price lower than both the MP_t and AP_t whereas if k < 0 the consumer responds to a price higher than both prices(Nieswiadomy and Molina 1991). In an increasing block tariff with a relatively small fixed charge (water meter rental amount) as in the case of NWSC, k > 1 implies that P* < AP < MP, and k < 0 implies that P* > MP > AP.

Since we defined water demand as a logarithmic function of explanatory variables in equation (1), we can estimate demand using the unobserved perceived price using the following equation:

$$ln\ W_{it} = \beta_c C_t + \beta_p ln P_t^* + YEAR + \ \varepsilon_{it} \dots\dots\dots\dots\dots\dots\dots\dots\dots\dots\dots\dots\dots. (4)$$

Perceived price, P_t^*, in equation (4) is substituted with equation (3) to get equation (5).

$$n\ W_{it} = \beta_c C_t + \beta_p ln\ [(1-k) ln\ MP_t + k\ ln\ AP_t] + YEAR + \ \varepsilon_{it} \dots\dots\dots. (5)$$

With algebraic manipulation, equation (5) can be re-written as:

$$n\ W_{it} = \beta_c C_t + \beta_m ln\ MP_t + \beta_a ln\ AP_t + YEAR + \ \varepsilon_{it} \dots\dots\dots\dots\dots\dots\dots\dots. (6)$$

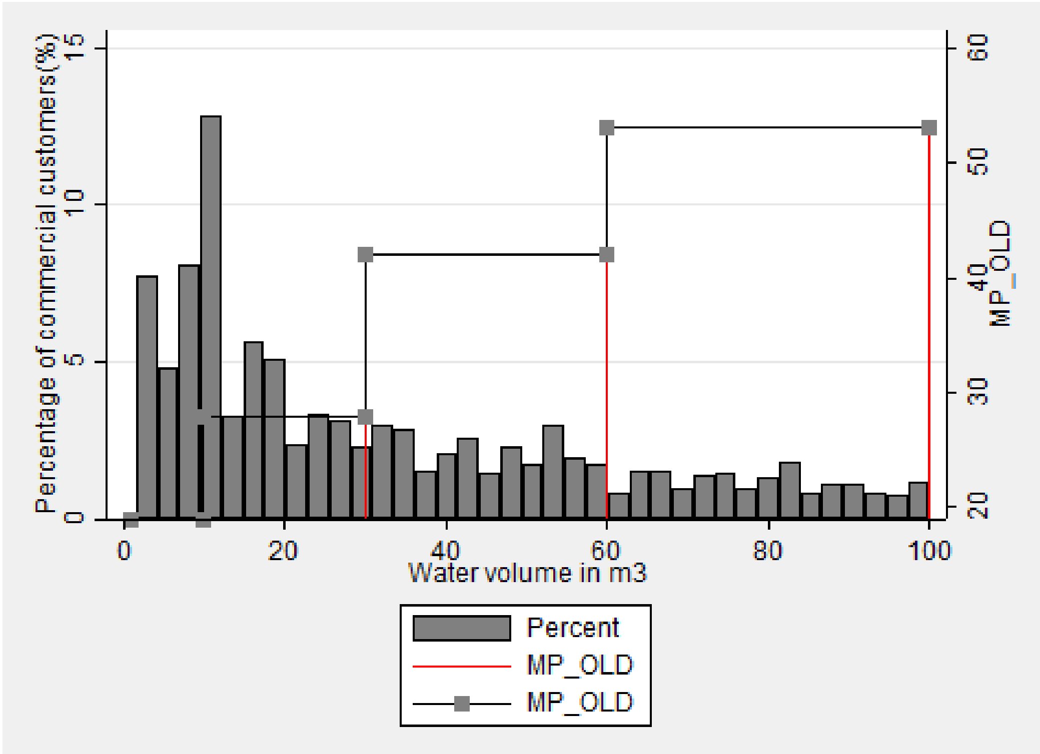
Where $\beta_m = \beta_p(1-k)$ and $\beta_a = \ \beta_p(k)$. Shin's perceived parameter k can then be estimated as $k = \ \frac{\beta_a}{\beta_m + \beta_a}$.

We also estimate separate models partitioning firms using the commercial classification described above and by size. We partition by size by calculating a firm's mean monthly water consumption. "Small" firms have a mean consumption under 10 cubic meters (n=12,319 firms). "Medium" sized firms have mean consumption between 10 and 1000 cubic meters (n=20,925 firms). "Large" firms have mean consumption greater than 1000 cubic meters (n=378 firms).

Testing inattention in water consumption

Two tests were run to test commercial water consumer's inattentiveness to water consumption in response to changes in marginal price and increment of IBP in October 2015. The first test is the "bunching" test that is discussed below. The second is the examination of consumer's response to the IBP rate changes implemented in October 2015.

Bunching Test



Test using change in Increasing Block Tariff rates

The water tariff change implemented in October 2015 resulted in disproportional increase of marginal price at distinct intervals. Commercial firms in the base block of 1 to 6 m^3 had a 9% price increase even though their marginal price remained unaffected. Firms consuming larger quantities, the marginal price increased disproportionately: 183% for 7 – 10 m^3, 88% for 11 – 30 m^3, 24% for 31 – 60 m^3 and 19% for 60 m^3 and above. If consumers respond to higher marginal prices, those experiencing high increases will reduce water consumption the most. However, if water is a primary input, we do not expect them to reduce water consumption but rather seek alternative ways of mitigating the costs such as increasing selling prices of their products or services. We therefore hypothesis that firms that consumed 7-10 and 11-30 prior to the tariff increase will reduce their water consumption more compared to the rest of the firms.

Results

Results in Table 2 show that models that use lagged marginal (Model A) or lagged average volumetric prices (Model B) show wrong-signed and statistically significant price elasticities. Using lagged average total price, however, we find a negative and statistically-significant price elasticity (Model C). Precipitation and temperature both show the expected results: water use decreases with increased precipitation and increases with increased temperatures. Year fixed effects show increasing consumption since 2012, though the growth in consumption declines from 2015 to 2016, the same time period over which tariffs increased.

Using a combination of lagged average price and lagged marginal price, we computed the k parameter (Model D) of 0.74. Our results indicate that consumers respond more towards average price than marginal price, though both have a sign inconsistent with theory.

Table 2. Commercial water demand: comparing price specifications

	A. Lagged marginal price	B. Lagged average volumetric price	C. Lagged average total price	D. Lagged marginal price and average price
ln(MP last bill)	0.082***			0.0183***
	(124.88)			(194.18)
ln(AVP last bill)		0.062***		0.0509***
		(30.15)		(25.41)
ln(ATP last bill)			-0.11***	
			(-47.26)	
Precipitation	-0.012***	-0.022***	-0.018***	-0.0544***
	(-5.99)	(-11.20)	(-8.96)	(-28.47)
Temperature	0.60***	0.74***	0.72***	0.948***
	(23.01)	(28.57)	(27.59)	(37.72)
Temp squared	-0.015***	-0.019***	-0.018***	-0.0237***
	(-22.95)	(-28.42)	(-27.61)	(-37.57)
Precipitation squared	0.00055*	0.0017***	0.0014***	0.00522***
	(1.72)	(5.29)	(4.42)	(16.89)
year=2013	0.12***	0.12***	0.12***	0.115***
	(31.99)	(31.51)	(31.81)	(30.91)
year=2014	0.13***	0.14***	0.13***	0.123***
	(30.55)	(33.02)	(32.78)	(31.05)
year=2015	0.17***	0.15***	0.14***	-0.0126**
	(40.90)	(35.90)	(33.52)	(-3.12)
year=2016	0.13***	0.074***	0.099***	-0.157***
	(30.87)	(17.47)	(23.56)	(-36.87)
Constant	-2.77***	-4.06***	-3.12***	-6.720***
	(-10.73)	(-15.78)	(-12.13)	(-26.94)
Observations	607888	577134	577134	577134
k				0.7355

Table 3. Response to lagged average total price, partitioned by size of mean monthly water use

	A. Small (<10 m^3)	B. Medium (10-1000 m^3)	C. Large (>1000m^3)
ln(ATP last bill)	-0.34***	-0.083***	-0.00062
	(-59.41)	(-32.08)	(-0.08)
Precipitation	0.0074*	-0.021***	-0.022*
	(1.88)	(-9.45)	(-1.85)
Temperature	0.36***	0.78***	0.75***
	(6.44)	(26.34)	(4.81)
Temp sq	-0.0090***	-0.019***	-0.019***
	(-6.34)	(-26.32)	(-4.89)
Precip squared	-0.0017***	0.0019***	0.0023
	(-2.86)	(4.97)	(1.17)
year=2013	0.050***	0.13***	0.21***
	(6.54)	(29.88)	(9.68)
year=2014	0.063***	0.14***	0.19***
	(6.57)	(30.69)	(8.61)
year=2015	0.073***	0.16***	0.15***
	(7.43)	(34.38)	(7.17)
year=2016	0.065***	0.12***	0.033
	(6.25)	(24.59)	(1.51)
Constant	-0.59	-3.59***	0.29
	(-1.07)	(-12.23)	(0.19)
Observations	101019	458639	17476

This pattern of results is similar when partitioning firms by the size of their water use: lagged marginal prices are always wrong-signed (positive) and statistically significant, and lagged average volumetric prices are positive and statistically significant for medium and large firms (results available on request). Results using lagged average total prices imply statistically-significant price elasticities of -0.34 for small firms and -0.083 for medium firms (Table 3). We find no statistically-significant impact of the tariff increase on large firms.

Table 4 shows results for models using lagged average total price for seven commercial categories. We find inelastic demand in six of the seven categories: construction, garages, industrial users, markets/retail, and small office buildings. We find no statistically significant impact of the price change for large office buildings, and our price measure has the wrong sign and is statistically significant for restaurants.

Table 4. *Demand by commercial category (lagged average total price)*

Ln(watervol)	Construction	Large Office	Garage	Industry	Market	Restaurant	Small Office
ln(ATP last bill)	-0.19***	0.012	-0.13***	-0.096***	-0.16***	0.034***	-0.13***
	(-6.01)	(1.55)	(-8.43)	(-12.49)	(-11.56)	(3.25)	(-17.13)
Precipitation	-0.016	-0.027***	-0.023*	-0.026***	-0.015	-0.042***	-0.0094
	(-0.40)	(-3.39)	(-1.78)	(-3.40)	(-1.29)	(-3.96)	(-1.40)
Temperature	0.72*	0.93***	0.44***	0.61***	0.20	1.01***	0.51***
	(1.68)	(9.01)	(2.71)	(6.38)	(1.36)	(7.47)	(5.96)
Temp sq	-0.017	-0.023***	-0.011***	-0.015***	-0.0052	-0.025***	-0.013***
	(-1.60)	(-9.03)	(-2.76)	(-6.42)	(-1.38)	(-7.55)	(-6.13)
Precip squared	0.0020	0.0025*	0.0015	0.0033***	0.00083	0.0047***	0.00029
	(0.25)	(1.91)	(0.71)	(2.64)	(0.42)	(2.66)	(0.26)
Year FEs	YES	YES	YES	YES	YES	YES	YES
Constant	-3.01	-4.27***	-0.25	-1.71*	1.86	-5.40***	-0.86
	(-0.70)	(-4.19)	(-0.16)	(-1.81)	(1.25)	(-4.04)	(-1.02)
N	3419	26675	10199	40957	12804	19398	37013

Table 4 summarizes the average total price elasticity results from estimating equation (1) for each of the seven categories identified earlier. With the exception of large offices and restaurants categories, elasticity estimates were negative and significant for the rest of the five categories. Even though restaurants had a positive coefficient, the elasticity estimate were significant.

Conclusion

The study has potential limitations. First, as mentioned earlier, our model does not incorporate firm characteristics such as building size (square footage) and number of employees as these details were not available. Although we do have information on the type of business, we can only match 16% of accounts to such a classification. Second, most commercial water users in Nairobi have alternative private water sources such as boreholes, water tankers and as a result, they do not exclusively rely on for NWSC for water supply. The current model does not incorporate details of alternative water sources, price and quantities due to data unavailability. Future survey-based work could quantify how prevalent alternative coping water sources are, by commercial class. However, this data is unlikely to become available for the universe of NWSC's commercial accounts.

The third limitation is that we assume that water bill arrears have no impact on demand price elasticity of water. Unlike commercial studies in high-income countries, it is common for NWSC customers to accumulate bill arrears which are included in the total amount owed. We use a definition of "total bill" that includes only billed consumption for the prior month. With arrears, however, consumers could easily be responding to the total bill that include arrears as opposed to the monthly billed consumption.

Finally, we have not modeled intermittent supply. Instead, we implicitly assume sufficient water availability from the NWSC to meet its customers' demands. Nairobi's system is supply-constrained and cannot meet demand; water is not delivered 24 hrs per day and 7 days per week. This could imply that (truncated) water demand is more influenced by water availability than its price, which is relatively low. In other words, commercial customers are on a section of their demand curve that implies they will consume as much water as they can have delivered to them. Future work will incorporate data on water supply to NWSC from its bulk water distributor.

The empirical results from the model indicate that consumers respond more towards average prices perceived from the water bill when compared to the marginal price. While the coefficients of average and marginal prices were positive, the coefficient of the lagged average total price were consistently negative and significant for both the overall model and the categorized data. This could imply that commercial water users in Nairobi could be inattentive to their water consumption, since they probably represent an insignificant proportion of their total production cost as in the case of Wang et al (2018). Instead for each billing cycle, commercial consumers could be paying attention their total bill in comparison to their volumetric water consumption (Wang et al. 2018). A behavioral model, such as a heuristic model could be used to test and hopefully explain the negative average total price coefficient.

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