Do Residential Water Consumers React to Price Increases? Evidence from a Natural Experiment in Santa Cruz

Shanthi Nataraj

Using a "natural experiment" from the city of Santa Cruz, California, we find that a 100 percent increase in the marginal price of water resulted in a 15-25 percent decrease in demand among high-use consumers. Our results suggest that price can be an effective water demand management tool, and that increasing-block pricing can successfully encourage water conservation among high-use households while maintaining overall affordability.

In recent years, water utilities in the western United States have found it increasingly difficult to meet the growing demand for water. The rapid growth in demand, coupled with the decreasing availability of new water supplies, has prompted many utilities to encourage water conservation among residential consumers.

Water utilities use a wide range of measures to promote conservation. During droughts, they often resort to water rationing, lawn-watering prohibitions, and other mandatory controls. At other times, they encourage voluntary water-saving measures; for example, several cities offer rebates for purchasing low-flow washing machines, or conduct public education campaigns.

Many economists argue that price can also be a powerful tool for encouraging conservation. If we disregard fixed costs and assume that water is a renewable resource (ignoring, for example, aquifer depletion), then an efficient market will set the marginal price of water (the price of one additional unit) equal to the marginal cost (the cost of producing one additional unit).

However, public utilities have historically set water prices far below marginal cost. There is an ongoing debate about how much prices must be raised in order to reduce water demand. While many studies have attempted to measure consumer reactions to price, it is difficult to disentangle the effects of a price increase from other factors that affect demand. Some studies have concluded that the typical city must increase water prices many times over in order to significantly affect demand. Large price increases are often infeasible, though, as many people consider access to water to be a basic right. If a public utility sets a high price for water, poor households may find it too expensive.

In this article, we use a "natural experiment" in the city of Santa Cruz, California in 1995 to estimate the effects of a price increase on demand. Santa Cruz employs an increasing-block pricing (IBP) system, which (in theory) encourages conservation among high-use consumers while maintaining overall affordability. Unlike previous studies, the nature of the increase allows us to separate the effects of price from the effects of weather and other factors that affect demand. Our results indicate that high-use consumers do react to price increases; a 100 percent increase in the marginal price of water resulted in a 15-25 percent decrease in demand among high-use consumers over a one-to three-year period. These findings suggest that IBP may be an effective tool for targeting households with high water use, while keeping water affordable for most households.

Do Prices Matter?

Over the past two decades, a growing number of water utilities have introduced IBP to augment revenues and promote water conservation. Figure 1 shows an example of an IBP system with three blocks. Consumers pay $1/unit for the first 10 units, $2/unit for units 11-20, and $3/unit for all units over 20. The first few units are inexpensive, so everyone, even the poor, can afford an essential amount of water. High-use consumers face higher marginal prices, encouraging them to conserve water.

However, there is an ongoing debate about whether residential water consumers actually respond to price changes. One argument in favor of the notion that they do not is that the typical water bill is a small fraction of income, so the price must be increased many times over before consumers notice. Another argument is that IBP structures are so complex that the typical consumer does not know what marginal price she faces. For example, readers of this article might ask

Figure 1. Example of a Three-Block IBP System

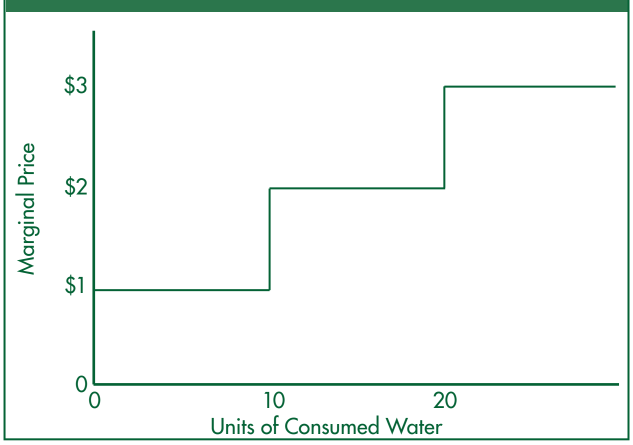
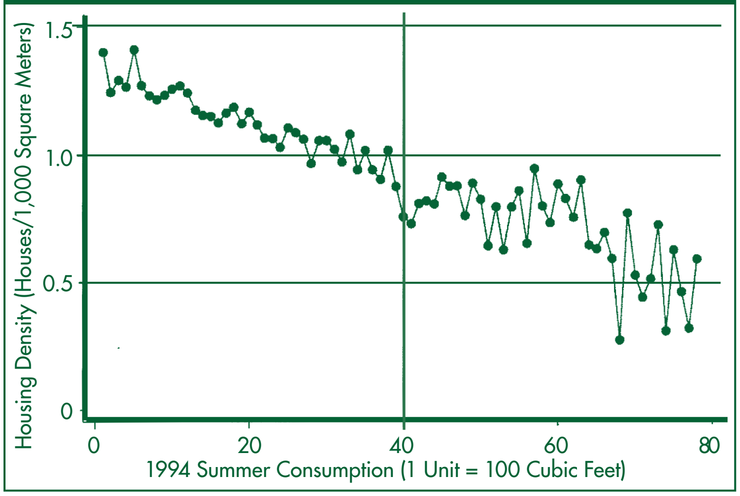


Figure 2. Housing Density by Summer 1994 Consumption



themselves whether they consider their water pricing structures when deciding how often to water their lawns.

To gain information about this issue, numerous studies have estimated how much a change in the price of water will affect the demand for water (the price elasticity). Unfortunately, it is difficult to get a “clean” estimate of the elasticity because many factors, other than price, affect demand. Studies that rely on price variation across cities often fail to account for why different cities set different prices. For example, if Tucson is more prone to water shortages than Phoenix, it may set a higher water price and its consumers may be more conservation-oriented. The lower demand in Tucson may be due not only to higher prices, but also to conservation measures practiced by its citizens. Longitudinal studies (those that consider price changes over time) can avoid this problem, but often fail to control for other factors that change concurrently with prices. Many significant price changes occur during droughts, when non-price policies, such as rationing and conservation education efforts, are also introduced.

A Natural Experiment

To determine how people react to price, we would ideally conduct a “controlled experiment” by randomly assigning high prices to some people (the “treatment” group) and low prices to others (the “control” group), and then measuring water use in the two groups. Since no water utility is known to have randomly assigned prices to its customers, we use a change in the IBP structure in Santa Cruz, California as a “natural experiment.” Although prices were not randomly assigned, the nature of the change provides us with comparable treatment and control groups.

Prior to 1995, Santa Cruz consumers faced a low marginal price for units one through eight (Block 1), and a higher marginal price for units nine and above (Block 2). In the summer of 1995, the city introduced Block 3, beginning at 40 units, with the Block 3 price set at approximately twice the Block 2 price.

We assign households to treatment and control groups based on their historical consumption (over 40 units and under 40 units, respectively). In the summer of 1995, the treatment group suddenly faced a 100 percent marginal price increase, while the control group faced a price increase of a few cents.

However, we cannot simply compare the treatment and control groups, because the two groups differ on the basis of characteristics that affect water use. For example, previous studies suggest that outdoor water use is one of the most important drivers of residential water demand; consumers with large yards consume much more water than consumers with small yards.

Figure 2 illustrates this relationship in Santa Cruz with a plot of housing density against summer 1994 water use (i.e., water use prior to the price change). Housing density is a “proxy” for lot size; we expect consumers with lower housing density to have larger houses/yards. The vertical line at 40 units on Figure 2 divides control households (to the left) from treatment households (to the right). Control households have higher housing density than treatment households; therefore, the two groups may not be comparable.

To overcome this dissimilarity between treatment and control households, we employ a “regression discontinuity” (RD) approach that exploits the sharp difference in marginal price for households that consumed just below and just above the 40-unit “discontinuity.” As shown on Figure 2, households that consumed 70 units of water in the summer of 1994 had much lower housing density (larger yards) than those that consumed ten units. However, households that consumed 45 units had similar housing density (yard size) as those that consumed 35 units. Control and treatment households near the discontinuity are also similar in terms of eight other characteristics that affect water use (income, number of residents, number of rooms, number of bedrooms, resident age, house age, population density, and home ownership). While these households are not exactly alike, they are as similar as we might hope for in the absence of a controlled experiment. Therefore, we can estimate price elasticity by comparing water use for the treatment and control households near the discontinuity. We use a “difference-in-differences” approach, which compares the change in the treatment households’ use, from 1994 to 1995, to the change in the control households’ use over the same period.

Table 1 presents the elasticity estimates over one-, two-, and three-year periods (1994-95, 1994-96, and 1994-97). The first column of results shows the price elasticity using all treatment and control households. These results indicate that increasing the marginal price by 100 percent resulted in a 25 percent decrease in demand among the treatment households from 1994-1995. The effect grew larger over time, with a decrease in demand of 50 percent among treatment households by 1997.

However, as discussed above, using all of the control and treatment households may not be appropriate, since the two groups differ along many dimensions. To address this concern, Table 1 also presents the elasticity estimates from the RD approach. The RD elasticity estimates are somewhat lower than the estimates for all households, and suggest that increasing the marginal price by 100 percent resulted in a 15-25 percent decrease in demand among households near the discontinuity.

The results presented in Table 1 represent the "short-run" price elasticity. In the context of water demand, we can think of short-run reactions to price increases as those that can be immediately implemented. For instance, during the first summer in which a consumer is faced with high water prices, she might water her lawn at night, rather than during the day, to decrease the amount of water lost to evaporation. If high water prices persist over several years, she can take additional conservation measures that are less easily implemented. When purchasing a new washing machine, she may opt for a low-flow model; when landscaping a section of her yard, she may choose plants that require less water. As we would expect, the short-run price elasticity for water is typically lower than the long-run price elasticity.

Most previous studies indicate that in the short run, the demand for water is inelastic (in other words, a 100 percent increase in price decreases demand by less than 100 percent). Our results fall within the range of previous estimates, but are lower (suggesting a smaller reaction to price) than most. Our findings may be somewhat lower than other studies' for two reasons. First, previous elasticity estimates may unintentionally include the effects of weather or non-price conservation measures, especially if they cover periods of drought. Second, our RD results are valid for a very specific group of consumers—those near the 40-unit discontinuity. These households are far from typical; their bi-monthly water use is approximately twice the average water use in Santa Cruz. If different segments of the population respond differently to price changes, then our results are not strictly comparable to previous studies that consider both low-use and high-use consumers.

Table 1. Price Elasticity Estimates

	All Households	Households Near Discontinuity		
		Within 20 Units	Within 10 Units	Within 5 Units
1994–1995	−0.263***	−0.108***	−0.206***	−0.238**
1994–1996	−0.453***	−0.168***	−0.199***	−0.158
1994–1997	−0.522***	−0.233***	−0.249***	−0.138

**** Significant at the 1% level. ** Significant at the 5% level.*

The relevance of the RD approach to only a small group of consumers could be considered a drawback. However, this high-use group is precisely the segment targeted by many water conservation programs. Recall that the intent of an IBP system is to encourage conservation among consumers who use significant amounts of water, while maintaining affordable prices for most households. The fact that the introduction of a third price block, targeted at high-use consumers, produced a 15-25 percent decrease in their demand, supports the use of IBP as a effective method for discouraging "excess" use.

Conclusions

Santa Cruz' introduction of a third price block in 1995 allows us to make a "clean" estimate of price elasticity using an RD approach. The RD elasticity estimates indicate that the introduction of a third price block, which doubled the marginal price faced by high-use consumers, decreased their demand by 15-25 percent over a one- to three-year period. The results suggest that price increases can be an effective tool for demand-side management, and that adding a block to an existing water pricing system can encourage conservation among high-use consumers while maintaining overall affordability.

Shanthi Nataraj is a Ph.D. student in the Department of Agricultural and Resource Economics at UC Berkeley. She can be contacted at shanthi@are.berkeley.edu or (510) 643-5414.

For additional information, the author suggests the following sources:

Hanemann, W.M. "The Economic Conception of Water." In *Water Crisis: Myth or Reality?* Eds. P.P. Rogers, M.R. Llamas, L. Martinez-Cortina. London: Taylor & Francis, 2006.

Renwick, Mary E. and Richard D. Green. "Do Residential Water Demand Side Management Policies Measure Up? An Analysis of Eight California Water Agencies." *Journal of Environmental Economics and Management,* Vol. 40, No. 1 (July 2000), pp. 37-55.

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