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Social Norms Information Treatments in the Municipal Water Supply Sector

Some New Insights on Benefits and Costs

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Abstract

Social norms comparisons are tools that are being used more and more often by energy and water utilities all over the world in order to induce households to conserve resources. Such conservation programs are appealing to utilities because they are an easy-to-implement alternative to raising prices and commonly result in short-term reductions in energy and water use of about 2-5%. However, the welfare effects of social norms programs are rarely discussed and assessed, especially in the context of municipal water supply. The purpose of this article is to propose a framework for identifying the costs and benefits of social norms comparisons and to provide plausible estimates for these components in the municipal water supply sector, using current knowledge for both developing and industrialized countries. Our calculations show that the outcome of a benefit-cost analysis of a social norms information treatment is highly uncertain and location-specific. We also present a simple benefit-cost analysis of a price increase that would lead to an equivalent initial reduction in household water use. The latter is found to be more likely to generate net benefits to the society as a whole in low- and middle-income countries, but we show that, in this case, households would have to bear most of the costs.

Key Words: social norms, benefit-cost analysis

JEL Codes: L95, D61, D80

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Social Norms Information Treatments in the Municipal Water Supply Sector: Some New Insights on Benefits and Costs

Dale Whittington and Celine Nauges*

1. Introduction

Water utilities often provide different types of information to their customers in order to accomplish multiple objectives. The most common channel of communication is through customers' water bills, which water utilities use to tell customers how much water they purchase, how their bill is calculated, and how much they need to pay. Some water utilities also regularly provide customers with information about the quality of the water supplied to ensure customers that it is safe to drink. Customers are also often given information (tips) in their water bills about actions they can take to conserve water.

Water utilities in both industrialized and developing countries are increasingly interested in providing customers with information about how much water other customers are using. This information is typically provided through customers' water bills and is called a "social norms" comparison. The objective of water utilities in providing social norms information treatments (SNITs) is to induce water savings behavior.

Social norms information is typically conveyed in two forms. The first, commonly called a "descriptive norm", is a simple statement about how the quantity of water a customer uses compares to the water use of other customers. The second, known as an "injunctive norm", includes feedback on the outcome of the comparison, for example in the form of an emoticon (🙂if the customer is using less water than others and 🙁 if the customer is using more water than others). Alternatively, a customer's behavior may be categorized as "excellent", "average", and "room to improve" (e.g., Jaime and Carlsson 2016). There is now robust evidence—reviewed in this article—from both industrialized and developing countries that SNITs result in modest, short-term reductions in water use of about 2-5%.

There is, however, much less evidence about whether implementing a SNIT is welfare-enhancing, i.e., whether a SNIT would pass a social benefit-cost test. The policy

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rationale for SNITs offered by most proponents of SNITs has two prongs. The first is that households with connections to piped water infrastructure for the exclusive use of their household members are using too much water, and that water conservation is socially desirable. The second is that raising water tariffs is politically infeasible and thus non-price policy instruments such as SNITs are needed to reduce water use to the socially optimal level. This policy rationale has superficial appeal because globally most water utilities, especially in developing countries, charge less than the average cost of supplying water and sanitation services. *A priori*, one would expect that a low-price signal might result in household water use in excess of the social optimum, and thus water conservation would increase social welfare. And advocates of SNITs are certainly correct that raising water tariffs is politically challenging.

However, the question of whether households are using too much or too little water is not straightforward. In many low- and middle-income countries, water utilities are charging such low tariffs that they do not have the financial resources to provide 24/7 services or to adapt to climate change (Nauges and Whittington 2017). In such circumstances, many households may use less water than is socially desirable, and broad water conservation policies may not be appropriate. In other cases, piped water systems have been designed to provide only minimal amounts of water to households for a few hours a day. For such systems, low water prices do not signal that households are using too much water (households are simply using all the water that the system can provide). In addition, about four billion people globally do not have private connections to piped water and sanitation infrastructure, and rely on water vendors or water sources outside the home. These households typically use much lower quantities of water than connected households, and their current water use is generally far below socially optimal levels. As such households become connected to piped distribution systems, it would be socially desirable for their water use to increase, and it is not obvious that they should receive SNITs (a signal to reduce their water use) with their new water bills. Even in advanced economies with 24/7 piped water and sanitation services, low water prices may not be a signal that water conservation is socially desirable. Households may be willing to pay the full social marginal costs of increased water use, but are unable to do so because they are constrained by a series of demand restrictions imposed by the water utility, and lack options to reveal their true preferences for increased supplies.

We believe that it is thus timely to think more carefully about the social costs and benefits of SNITs in the municipal water supply sector. In the next section of the paper, we summarize what is known about the effectiveness of SNITs in reducing household energy use and compare these findings with the more limited evidence available for the water supply sector.

In the third section, we discuss four main categories of benefits and costs that accrue to various stakeholders and should be included in a benefit-cost analysis of SNITs in the municipal water supply sector. In the fourth section, we present the results of illustrative calculations of the costs and benefits of a SNIT based on our knowledge of the sector and existing evidence from the literature. We show that the outcome of an economic analysis of a SNIT is highly uncertain and that there are plausible circumstances in which SNITs will result in either minimal or negative net social benefits. We conclude that water utilities need to undertake careful economic analysis of a SNIT for their particular local circumstances to ensure that the policy will be welfare enhancing.

In the fifth section, we compare the social costs and benefits of a SNIT to those resulting from an increase in water prices. In the sixth, concluding section of the paper, we argue that in most cases SNITs are not a viable substitute for comprehensive water tariff reform. Indeed, the allure of SNITs may distract water utilities from the hard, but necessary, political work required to increase water prices.

2. Literature Review of Social Norm Information Treatments: Water and Energy Sectors

The empirical literature on social norms has grown rapidly over the last decade, with most of the pioneering work done in the energy sector. Although our focus is primarily on the municipal water supply sector, in this section we review the most influential articles assessing the impact of SNITs on both energy and water use. We restrict our discussion to studies that used Randomized Controlled Trials (RCTs), either in developing or industrialized countries, and that were published in economic journals.[1] Interestingly, most studies in both the energy and water sectors agree on a relatively small effect of SNITs on households' energy or water use, usually in the range of a 2-5% decrease in use, with differences depending, among other things, on the characteristics of

[1] A number of articles have been published in sociology and psychology journals, but they are not discussed here. See, for example, Karlin et al. (2015) for a meta-analysis covering 42 studies assessing the effects of feedback on energy conservation.

the program being put in place and the time between the intervention and the assessment of its effect.[2]

Several types of information treatments have been tested. First, households have been provided with technical advice on how to reduce water or energy use (see, for example, Ferraro et al. 2011, for an intervention in the water sector in Cobb County, Georgia, US). Second, information has been provided on goal setting and plan making, e.g., asking households to write down a personal goal in terms of water use reduction (Datta et al. 2015, in Belén, Costa Rica). Third, some experiments have attempted to raise awareness of the need to conserve water or energy, e.g., the "weak social norm treatment" in Ferraro et al. (2011), and the "information component" in Jaime and Carlsson (2016, in Jericó, Colombia). Fourth, households have been provided with social norms information (social comparisons). The latter is the most common form of SNIT, with a distinction commonly made between treatments that only provide information on what others do ("descriptive norms") and treatments that, in addition, convey a message and some feedback on the particular household's behavior. This second form of social norm treatment is commonly termed an "injunctive norm" and can include messages categorizing households into groups (e.g., "great", "good" or "below average" in Allcott 2011; or "excellent", "average", and "room to improve" in Jaime and Carlsson 2016) or emoticons (e.g., stickers with a frowny or a smiley face in Datta et al. 2015).

The group to which a specific household is compared varies across studies. In Allcott (2011), a household's comparison group comprised approximately 100 houses in geographical proximity, with similar square footage and source of heating (electricity or gas). In Ferraro and Price (2013), the social comparison used the median household water use in the county as a basis for comparison. In one experiment, Datta et al. (2015) used the average water use in the neighborhood as a benchmark for comparison. In another experiment, they used the average water use in the city. Brent et al. (2015) used households that were estimated to have the same number of occupants and similar irrigable area (and were customers of the same utility) as a benchmark for comparison.[3]

[2] We do not discuss articles about the effect of social norms on technology adoption (e.g., Herberich et al. 2011, on the adoption of energy-efficient light bulbs). As far as we know, no such study has been conducted in the water supply sector.

[3] Note that most utilities would not have such data on their customers' household size, especially utilities in developing countries.

Treatments also differ in terms of the timing and duration of their implementation. In some cases, the SNIT was implemented just once (e.g., Datta et al.'s intervention to reduce water use in Belén, Costa Rica), while, in others, information and feedback were provided to households on a regular basis over several months or years (e.g., Allcott (2011) sent Home Energy Reports to US households monthly, bimonthly, or quarterly depending on the utility).

In most of the articles reviewed here, several non-price treatments were tested, either in isolation or in combination with other conservation programs, and were compared based on their effectiveness in terms of reduction in energy or water use. Most studies in both the energy and the water sector have reached similar conclusions in terms of the magnitude of the treatment effect of SNITs on energy and water use. Information treatments have resulted in statistically significant reductions in households' energy and water use in the range 2 to 5%, with greater reductions in resource use generally observed when the intervention includes social norm comparisons (compared to interventions providing technical advice, tips, or general information). For example, the provision of Home Energy Reports was found to induce a reduction in households' energy use of 1-3% on average (Allcott, 2011; Ayres et al. 2013). In the water supply sector, Ferraro and Price (2013) estimated that the effect of information treatments varied from 1% (for provision of technical advice only) to 5% (when the treatment included technical advice, a letter emphasizing the importance of conserving water, and a social norm comparison). Similar impacts were measured by Brent et al. (2015) using data for more than 7,000 households from three cities in California. Social norm comparisons were found to decrease water use by 5% in two out of three cities.[4]

These examples are for the United States, but impacts of similar magnitudes have been estimated in developing countries. Jaime and Carlsson (2016) found that information treatments including both descriptive and injunctive norms, along with information on the environmental impacts of water use, induced a reduction in water use of 4.6% in Jericó, Colombia. Datta et al. (2015) estimated that an injunctive social norm, using as the basis for comparison the median neighborhood consumption, induced a reduction in water use varying between 3.7% and 5.6% in Belén, Costa Rica.

Ito et al. (2015) compared moral suasion (a message requesting voluntary conservation) with a pure financial incentive (an increase in electricity prices during

[4] In the third city, the average treatment effect was negative but not statistically significant.

critical peak demand days and hours) in an experiment conducted in Kyoto (Japan). The peak pricing treatment increased the electricity price by 40, 60, or 80 cents per kilowatt-hour in addition to a baseline price of around 25 cents per kilowatt-hour. They found that their moral suasion treatment induced an 8% reduction in electricity use, while higher electricity prices led households to decrease their peak hour electricity usage by 14 to 17%. There was no evidence of an increase in consumption outside the peak hours in either of the two groups, but some spillover effects were observed in the group which received economic incentives, i.e., those households who received the peak pricing treatment also reduced electricity usage outside the peak hours (by 2 to 6%, depending on the time of the day and season).

Brent et al. (2015) analyzed the interaction of SNITs with existing conservation programs. They did not find any evidence that social norms crowd out existing conservation programs. In the two Californian cities they studied, where information treatments resulted in statistically significant reductions in household water use, households that received a Home Water Report increased participation in the programs (free home water audits and rebates for efficient toilets or irrigation controllers) by 6 percentage points. List et al. (2017), using data on energy demand for 200,000 US households, found evidence for complementarity between a SNIT (through the provision of Home Energy Reports) and a financial rewards program.[5] The reduction in electricity use was 40% greater for those households who were offered the financial rewards program (compared to households who received only the Home Energy Reports). List et al. (2017) suggested that this complementarity was driven primarily by financial rewards incentivizing low-energy users, while the information treatment was most effective on high-energy users. These findings differ from those of Pellerano et al. (2017), who showed that financial incentives (in the form of information provided to households on expected savings from reduced energy use) did not strengthen the effect of normative messages and may even have crowded out conservation efforts. These findings were based on a RCT conducted on residential customers served by the Quito Electric Company (Ecuador). The first treatment group received only a SNIT (comparison of the household’s own consumption with the consumption of the “average household”), while the second treatment group was also provided with details on how much money the household could save by reducing its electricity use to the comparison benchmark.

[5] Under this program, households earn points by changing their monthly energy use. These points can be redeemed for consumer goods.

Numerous researchers have debriefed households about the changes they made in electricity or water use after the implementation of SNITs. Households frequently reported changes in day-to-day behaviors, e.g., adjusting thermostats and closing window blinds (Allcott 2011). Similarly, Ito et al. (2015) found that households in Kyoto responded to financial incentives (an increase in peak electricity prices) by changing their lifestyles (habits in terms of energy consumption), but they observed no significant effect in terms of the purchase of more energy-efficient equipment. In contrast to studies from the social psychology literature, researchers investigating SNITs in the energy and water supply sectors have found no evidence of "boomerang effects," i.e., of low resource users increasing their energy or water use after learning that they compare favorably to their peers (Schultz et al. 2007).[6]

The findings regarding the persistence of the effects (the length of time the decrease in water or energy use lasts) are inconclusive, although most studies seem to find evidence for decay over time. In Allcott (2011), there is no evidence of a decline in the treatment effects related to the provision of Home Energy Reports after two years of continuing treatment. Conclusions are different in Ferraro and Price (2013) and Ayres et al. (2013). Ferraro and Price (2013) found that the difference in water use between households in Cobb County (Georgia, US) who received the strong social norm treatment (including technical advice, a letter emphasizing the benefits of water conservation, and a social norm comparison) and households in the control group was approximately 5.6% in the month following the intervention, but this difference declined by 35% four months later. Ayres et al. (2013) identified a pattern of "action and backsliding," i.e., the reduction in electricity use was found to be quite substantial just days after households received their initial reports, but these treatment effects decayed over time. These results thus cast doubt on the persistence of the treatment effects once the intervention stops, which is consistent with findings discussed earlier in this section that households primarily respond to SNITs by changing consumption habits rather than investing in resource-efficient equipment. Ito et al. (2015) found that economic incentives (in the form of peak pricing) had much more persistent effects on electricity use in Kyoto (Japan) than moral suasion.

Other issues that have been considered in this literature include heterogeneous treatment effects and possible spillover effects in the population. Ferraro and Miranda

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[6] Some authors have argued that the use of injunctive norms (which convey the message that resource conservation is pro-social) has prevented the boomerang effect, e.g., Cialdini et al. (1990).

(2013) found heterogeneous responses to their strong social norm message among the treated households from Cobb County, Georgia. Richer households and large water users were found to be more responsive to the full social norm intervention. Similar findings were obtained for the SNIT implemented by the three water utilities in California studied by Brent et al. (2015). In the city of Jericó in Colombia, Jaime and Carlsson (2016) found evidence of spillover effects. Households that were not initially targeted by the intervention decreased their water use. However, they could not identify the main driver of these spillovers (whether geographical or social proximity).

Some of the studies reviewed have gone a step further than simply estimating the expected change in water or energy use, and have attempted to assess the impact of the SNITs using simple cost-effectiveness or cost-benefit analyses. Datta et al. (2015) estimated the benefit-cost ratio of their "neighborhood comparison" and "plan-making" treatments (if extended to the entire population of Belén) to vary between 6 and 13. Their cost estimate was simply the financial cost of printing and mailing stickers and postcards to customers; their benefit estimate was households' monetary savings in their water bills induced by the reduction in water consumption (but note that households' monetary savings are simply revenue losses to the utility). Ferraro and Price (2013) estimated the cost-effectiveness of their social norm intervention targeting water use in Cobb County, Georgia to be roughly USD 0.15 per cubic meter saved. The cost of the information treatment was assumed to be the cost of sending one letter by first class mail and a follow-up tip sheet four weeks later in the same manner. Ferraro and Miranda (2013) updated the above estimate by considering the change in households' water use over a three-year period and estimated the cost-effectiveness to be around USD 0.10 per cubic meter reduction in household water use (or 10 cubic meters for every USD 1 spent on the SNIT).

Brent et al. (2015) reported a higher cost-effectiveness ratio, at USD 0.69 per cubic meter reduction in household water use for the three cities in California in their study. The higher estimated cost per cubic meter reduction in household water use in Brent et al. (2015) is primarily driven by the higher cost of the information treatment in this study. WaterSmart, the company in charge of implementing the Home Water Report program in the three cities, charged utilities an average of USD 10 per customer per year. This included the mailing of eight home water reports (in print form) for the first utility; nine (in print form) for the second utility; and 13 (by e-mail) for the third utility. WaterSmart's charges included more than just the SNIT. WaterSmart also played an active role in promoting water conservation in the three utilities. For example, it performed data analysis and conducted consumer surveys. The treatment period that was considered in the calculation of the cubic meters reduction in household water use was also shorter than in Ferraro and Miranda (2013).[7]

In Allcott (2011), the provision of Home Energy Reports to households in 12 US utilities was found to have an average cost-effectiveness ratio of about 3.3 US cents per kilowatt-hour reduction in household use, where cost-effectiveness is defined as the annualized cost of printing and mailing Home Energy Reports divided by households' reduction in kilowatt-hours per year. The cost of the information treatment was defined as the annualized cost of printing and mailing the Home Energy Reports via US mail (costs were kept confidential but authors estimated that they should be on the order of one dollar per letter). Reports were sent monthly, bimonthly, or quarterly depending on the utility.

A few articles summarized in Table 1 include a theoretical framework to describe the possible mechanisms of SNITs and the channels through which they could impact households' choices and welfare. Ferraro and Price (2013) use a conceptual framework borrowed from Levitt and List (2007) in which the household's utility is the sum of two terms: a utility component driven by consumption and a moral payoff component. Both terms depend on households' water use and a set of individual characteristics. Moral costs are assumed to increase as the household's behavior becomes more closely scrutinized and deviates more from the perceived social norm. The authors use this conceptual framework to derive assumptions on the relative impacts of three interventions: technical advice, highlighting the importance of conserving water, and social norms comparison. Technical advice is assumed to affect household's utility only through the scrutiny component, while the last two components highlight the importance of a social norm comparison and thus are expected to have stronger effects on the household's utility.

In Ito et al. (2015), the household's utility function consists of three additive components: utility derived from the consumption of electricity, utility derived from the consumption of a numeraire, and utility derived from electricity conservation, which depends on the quantity of electricity that is voluntarily saved by the household when receiving moral suasion[8] and on the frequency of interventions. In their framework, the

[7] The treatment period was roughly one year in the three cities studied in Brent et al. (2015).

[8] The third utility component is equal to zero when households receive economic incentives only.

(voluntary) contribution of households in terms of electricity savings is interpreted as a charitable contribution (or warm glow effect), and there is no disutility or moral cost induced by the moral suasion intervention.

Allcott and Kessler (2015) extended Levitt and List (2007)'s framework to incorporate a parameter that captures consumers' imperfect information or behavioral bias. This parameter is assumed to affect choices but not experienced utility. The moral payoff component in the utility function includes two terms: the first one is a constant (*m*), which is positive or negative depending on whether a consumer likes or dislikes receiving a "nudge" from a SNIT, regardless of their energy use.[9] The second term is described as a moral or psychological tax; it is similar to the moral cost payoff in Levitt and List (2007) in that it depends on energy consumption and its comparison with a social norm. The introduction of a SNIT can thus affect consumers' choices and welfare through three channels: 1) a change in energy use if the SNIT provides new information to consumers (re-optimization); 2) *m*, which reflects whether consumers like or dislike nudges; and 3) the moral tax, which depends on consumers' energy use relative to a social norm.

Brent et al. (2017), building on Allcott and Kessler (2015)'s theoretical framework, designed experiments to explore the relative importance of moral costs versus the information (re-optimization) component in driving households' behavioral changes. Separating the two effects is difficult since high water users are exposed to a stronger social norm message because they are farther from the norm, but also have lower opportunity costs of water savings (and hence are able to save more money) than low-water users. In order to decouple the strength of the message from the household's level of water use before the information treatment, the authors designed a new type of social norm that compares a household's water savings with its peers' rate in percentage terms.[10] Their findings suggest that SNITs operate primarily as a moral tax on consumption in excess of the norm, rather than helping households re-optimize their water use.

[9] There is anecdotal evidence that some customers dislike social norm interventions. In Allcott (2011), it is documented that some targeted households asked to stop receiving the Home Energy Reports on the basis that comparisons were "unfair or inaccurate" and/or that the reports were a "waste of resources".

[10] For example, the household would receive information such as: "Your neighbors used 19% less water last month compared to 2013. You saved 23% on your July water bill compared to 2013."

However, few authors have use their theoretical frameworks to actually estimate the welfare effects of SNITs. To the best of our knowledge, Allcott and Kessler (2015) provide the only empirical assessment of the magnitude of moral costs and benefits induced by SNITs. These authors surveyed US households to estimate their willingness-to-pay for four more Home Energy Reports after households had already received SNIT for a year. They interpret their findings to suggest that the moral costs imposed by the SNIT are about half of the monetary value of the cost savings (i.e., bill reduction due to natural gas savings) that households obtained during the first year they received SNITs.

Table 1 summarizes the main characteristics and findings of the empirical studies discussed in this section.

Table 1. Summary of Main Findings from the Recent Literature Measuring the Impact of Social Norms on Water or Energy Use

Reference	Geography	Intervention period	Target	Sample size	Treatment	Impact Time	Impact Δ in use
Ferraro et al. (2011)	Cobb county, Georgia (US)	May 2007	Water use	100,000 HH +	Technical advice	Jun-Sept 2008 Jun-Sept 2009	Δ in use: not statistically significant
					Technical advice + importance of conserving water	Jun-Sept 2008 Jun-Sept 2009	Δ in use: not statistically significant
					Technical advice + importance of conserving water + social comparison (county median use)	Jun-Sept 2008 Jun-Sept 2009	Δ in use: -2.6% in 2008 -1.3% in 2009
Ferraro and Price (2013)	Cobb County, Georgia (US)	May 2007	Water use	100,000 HH +	Technical advice	Jun-Sept 2007	Δ in use: -1%
					Technical advice + importance of conserving water	Jun-Sept 2007	Δ in use: -2.7%
					Technical advice + importance of conserving water + social comparison (county median use)	Jun-Sept 2007	Δ in use: -4.8%
Datta et al. (2015)	Belén, Costa Rica	Once, in July 2014	Water use	5,626 HH	Descriptive norm: neighbourhood median consumption + emoticon	Aug and Sept 2014	Δ in use: -3.7% to -5.6%
					Descriptive norm: city median consumption + emoticon	Aug and Sept 2014	Δ in use: not statistically significant
					Goal setting and planning intervention	Aug and Sept 2014	Δ in use: -3.4% to -5.5%

Reference	**Geography**	**Intervention period**	**Target**	**Sample size**	**Treatment**	**Impact Time**	**Impact Δ in use**
Brent et al. (2015)	US, California (3 utilities)	2011 – 2013 Still ongoing in one utility	Water use	7,361 HH	Social comparison + personalized recommendations to save water	After receipt of the first home energy report	Δ in use: -4.9% and -5.1% in two utilities, not significant in the third
Jaime and Carlsson (2016)	Jericó, Colombia	Monthly, from Jan to Dec 2013	Water use	1,857 HH	Consumption reports including descriptive and injunctive norms + information on environmental impacts	Jan-Jun 2013	Δ in use: -4.6%
						Dec 2013	Δ in use: -5.4%
Allcott (2011)	US (12 utilities)	Started late 2009 at different times	Energy use	Nearly 600,000 HH	Home Energy Report: social comparison + efficiency standing (injunctive norm) + conservation tips	Varying across utilities	Δ in use: -1.4% to -3.3% (unweighted mean: -2.0%)
Ayres et al. (2013)	SMUD utility (California) US	Started Apr 2008	Energy use	SMUD : 84,000 HH	Home Energy Report	Apr 2008 - Apr 2009	Δ in use: -2%
	Puget Sound Energy (WA) US	Started Oct 2008	Energy use	PSE: 84,000 HH	Home Energy Report	Apr - Oct 2008	Δ in use: -1.2%
Ito et al. (2015)	Kyoto (Japan)	Summer of 2012 and winter of 2013	Electricity use	691 HH	Moral suasion: message requesting voluntary conservation	Few days after treatment	Δ in use: -8%, not persistent
					Economic incentive: higher electricity price	Few days after treatment	Δ in use: -14% to -17%, persistent
Pellerano et al. (2017)	Quito (Ecuador)	March 2014	Electricity use	27,634 HH	Social comparison + energy-savings tips	Apr - June 2014	Δ in use: -1%

	Social comparison + financial incentives (price salience)	Apr - June 2014	Δ in use: -1% (possible crowding-out effects)

3. Toward a Welfare Assessment of Social Norms in the Water Supply Sector: Four Main Components

A social benefit-cost analysis of a SNIT should include four main categories of costs and benefits that accrue to various stakeholders. First, there are real resources costs associated with the delivery of the information treatment. Second, if the SNIT is effective in reducing household water use, the water utility will experience real cost savings as a result of not having to supply as much water as before the SNIT. Third, households may suffer a welfare loss (or even possibly experience a welfare gain) as a result of the SNIT. Fourth, if less water is withdrawn from surface or groundwater sources to supply the utility's customers, some people may experience welfare gains from the resulting enhanced environmental (ecosystem) quality. In addition, other people may experience welfare gains because less water use by households entails less wastewater discharged, and thus the negative externalities associated with wastewater discharges are smaller.

In this section of the paper, we discuss each of these four components of the welfare change due to the SNIT and their likely magnitude in a typical water utility. However, we argue that there is a great deal of heterogeneity in the magnitude of each of these four components across water utilities, and thus considerable uncertainty about the results of a benefit-cost analysis of a SNIT in a specific locality at a given time.

3.1. Costs of the Delivery of the Information Treatment

Advocates of SNITs often consider these resource costs to be so minimal ("just a letter") that they are hardly worthy of mention. Although not large on a per household basis, the costs of SNITs are nontrivial and should not be ignored in a social benefit-cost analysis. The best available estimates of the costs of SNITs are not what it has cost researchers to supply information to utility customers, but rather the financial costs that private firms (e.g., WaterSmart) charge utilities to design and deliver such services. The financial costs needed to cover the printing and mailing of letters to consumers are typically in the range of USD 1-2 per household per year depending on the data analytics provided and the size of the customer base (Allcott 2011).[11]

[11] Brent et al. (2015) reported a cost of USD 10 per customer. This cost included customer surveys and data analyses undertaken by WaterSmart, which we consider not to be essential to implement a SNIT.

3.2. Cost Savings to Utility

If a SNIT slightly reduces household water use, households' water bills will fall, which will result in a decrease in the utility's revenues. The financial gain to households from their reduced water bill is a financial loss to the utility, and this transfer payment will cancel out in the benefit-cost calculation. However, there is a real resource cost savings to the utility from not having to produce as much water as before the SNIT, and these cost savings are a benefit to the owners of the water utility. From a benefit-cost perspective, any cost savings to a publicly-owned water utility from a SNIT ultimately accrue to taxpayers, assuming the utility managers are not engaged in rent-seeking behavior (Davis 2004).[12] For a privately-owned utility, cost savings would flow to shareholders.

Because piped water and sanitation infrastructure is so capital intensive, the reduction in household water use from a SNIT would be most beneficial if it resulted in reduced or deferred capital expenditures. But the small size and short duration of the treatment effect suggests that SNITs are unlikely to defer capital expenditures because of the uncertainties associated with long-term master plans for water infrastructure. Future estimates of water use are simply not precise enough for the small, short-term treatment effect from a SNIT to reduce or defer capital costs. Information treatments may, however, be quite helpful in the management of droughts because in this case the reduced household water use may enable the utility to improve the allocation of limited water supplies among customers until the drought is over, even if the SNIT does not save capital costs (Ferraro 2011).

The majority of the total annual costs associated with the delivery of piped water services are capital costs. A common rule of thumb is that capital costs account for about 60-65% of total annual costs, and the remaining 35-40% are operation and maintenance (O&M) costs (Whittington et al. 2009). Roughly half of the O&M costs of most water utilities are labor costs, and for most utilities these labor costs are best considered as fixed costs in the short run. The resource cost savings that would result from small temporary reductions in water use due to a SNIT would be largely the reduced costs for electricity and chemicals that are no longer needed, at most 25% of O&M costs, or perhaps 10% of the total average cost of producing a cubic meter of water.

[12] Globally, most water utilities are publicly owned.

As an illustrative calculation of the value of the resource cost savings to the utility from a SNIT, we assume total annual costs for piped water services of USD 1.50 per cubic meter (not including wastewater collection and treatment), probably typical for many low- and middle-income countries. O&M costs per cubic meter would be roughly USD 0.60 (0.4 x USD 1.50 = USD 0.60). If O&M costs per cubic meter could be reduced by 25% in the short run in response to a SNIT, the resource costs savings to the utility might be on the order of USD 0.15 per cubic meter of reduced household water use.

If a household used 15 cubic meters per month and a SNIT reduced its water use by 3%, the cost savings to the utility would be USD 0.07 per household per month [15 cubic meters per month x 0.03] x [USD 0.15 per cubic meter], or about USD 0.8 per household per year. This resource cost savings (a benefit) is of the same general order of magnitude as the resource cost of implementing the SNIT.

In low-income countries, wastewater is often not collected; even if collected, it is rarely treated. However, in high-income countries where wastewater is routinely collected and treated, the SNIT would result in an additional resource cost savings on the wastewater side. If we assume total annual costs for water and wastewater services in high-income countries of USD 5 per cubic meter (USD 2 for water and USD 3 for wastewater), O&M costs would be about USD 2 per cubic meter and the costs savings for the utility would be on the order of USD 0.50 per cubic meter of reduced household water use. If we consider a household using 15 cubic meters per month and a 3% treatment effect of the SNIT, the utility would save roughly USD 2.7 per year [15 cubic meters x 0.03 x 12 months per year x USD 0.5 per cubic meter].

These simple calculations of resource cost savings illustrate that, other things equal, SNITs are more likely to pass a benefit-cost test in locations where the utility collects and treats wastewater than in locations where sewers and wastewater treatment facilities have not yet been installed, such as cities in most low-income countries.

3.3. Households (Utility Customers)

Globally, most water utilities sell piped water services below their total average cost, and rely on subsidies from higher-level government to cover the financial deficit. In low-income countries, most utilities sell piped water services far below total average cost, often for less than O&M costs (Danilenko et al. 2014). One implication of the fact that most utilities sell water below total average cost is that in many places the marginal value of water use to most households is likely to be quite low. Also, as water utilities move closer to cost recovery prices, the marginal value of water to the household will increase.

Households will pay a lower water bill as a result of reducing their water use in response to a SNIT, but these cost savings to households will be small because prices are low, and, as noted, the cost saving to a household is a corresponding reduction in the water utility's revenue, and the transfer payment cancels out in the summation of benefits and costs. But the net welfare effect on households that results from the SNIT remains difficult to discern.

There are several plausible narratives about how households process the SNIT and the resulting welfare consequences they could experience in addition to the cost savings they receive as they adjust their water use in response to this new information. At first glance, it may appear that it would be impossible for a household to suffer a welfare loss because the reduction in water use is voluntary, i.e., a utility-maximizing household would not reduce its water use in response to the SNIT unless this reduction in water use increased its utility. However, there are three main channels through which SNITs are commonly assumed to affect households' welfare by providing information that: i) increases customers' attention to their water use behavior and enables them to better optimize water use decisions and thus increase welfare; ii) imposes a moral or psychological tax (cost) induced by social comparisons; and iii) results in a moral or psychological benefit that arises from the household making a positive contribution to the welfare of others (Allcott and Kessler 2015; Brent et al. 2016). The moral tax could arise because the household feels the utility is being intrusive by providing the SNIT ("Big Brother" is watching too closely what the household is doing), or because the household feels pressured by the state to reduce its water use when it does not really want to do so. If the household experiences a moral or psychological tax induced by a social comparison, the SNIT may still increase its welfare if the financial cost saving from a reduced water bill is greater than the moral or psychological costs. But, because the financial cost savings to the household is a transfer payment, the SNIT can both increase the household's welfare and contribute to a decrease in social welfare through the creation of a moral or psychological cost.

Information Channel

There is evidence that consumers are rarely perfectly informed when making decisions about resource use (Wichman 2015). Information on water use and prices comes through bills which are not always easy to understand. Water bills often cover several months, and water use is sometimes estimated instead of actually being measured. In addition, tariffs may be complex and hard to understand. Consumers may be informed about their total water use over a multi-month period without receiving any information about the quantities of water they used for different purposes, e.g., outdoor water use, toilet flushing, washing machines, etc. Moreover, households do not usually know precisely the performance of their appliances in terms of water-use efficiency, i.e., how to best use water to reach an expected level of service (for example, the best time of the day to water the lawn). SNITs that provide tips to conserve water or information on the average water use of various appliances may help customers adjust their behavior to optimize their water use.

Also, households may have misperceptions about the social value of water in the environment. In regions where water is scarce, there may be a social value associated with water conservation (leaving more water in surface water bodies or groundwater aquifers may benefit the environment or other sectors of the economy such as irrigated agriculture). Households may not be aware of this social value of water. Conservation messages may lead customers to change their perception about the social value of water in the environment.

Imperfect information and misperceptions may shift a consumer's demand curve and distort her choices in a sub-optimal way. If a SNIT provides accurate information and/or helps correct misperceptions, then a SNIT could be welfare-increasing for consumers. However, if the SNIT provides information that is misleading, then a SNIT may distort consumers' choices even more and lead to a decrease in welfare. This may happen if the SNIT provides a household with a social comparison that is inaccurate. Because utilities do not have information on the number of household members, household size cannot be used to compare a household's water use and that of its neighbors. A simple average of water use across households in a neighborhood or community, without paying attention to the number of members in each household, will undoubtedly provide some households with misinformation (see Hahn and Metcalfe 2016, for a discussion of this issue).

For example, a household with eight members may be told it is using much more water than its neighbors and receive an emotive face with a frown, signaling that the household is being socially irresponsible and wasting water. But this comparison would be misleading if the average household in the community has four members. On a per capita basis, the targeted household may be using less water than its neighbors. If this misinformation leads the household to feel social pressure to reduce its water use, then it is plausible that its reduction in water use will lead to a welfare loss because the household has acted on misleading information. Similarly, if a household with only two members receives a smiley face, signaling that it is doing great, it may increase its water use (a rebound, or "boomerang" effect). However, if the social norm comparison was based on a household with four members, the smiley face message is misleading. In this case, the social norm message leads to wasteful water use and increasing losses by the utility because it has to produce more water that is actually of little value to the household.

Another example would be if the utility sent misleading information about the regional water situation, either out of ignorance or design. These effects are similar to the welfare losses that can occur due to false advertising (see. e.g., Glaeser and Ujhelyi 2010). Interestingly, the existing literature on SNITs usually disregards the possibility of the SNIT providing false or inaccurate information.

In sum, while SNITs are often assumed to induce customers to make "better" choices and hence to be welfare-improving, we believe that the problem of misinformation is pervasive in this field because of the way social norms comparisons are typically constructed, in particular, the inability to account for household size.[13]

Moral/Psychological Tax or Benefit

In Allcott and Kessler (2015), one of the rare studies that try to assess the welfare effects of SNITs, moral utility consists of two components: 1) a constant term that simply captures whether households like or dislike SNITs, and 2) a second component that depends on how the household's level of water use compares to the social norm. The latter component is interpreted as a "moral tax" when a household's water use is above the norm, and in this case a SNIT decreases welfare. On the contrary, if water use is below the norm, the household gets a "moral subsidy" (for doing well) and its welfare increases if it receives a SNIT.

In this conceptual framework, the household receives benefits only from its own contribution to water savings. These benefits could derive from a warm-glow effect. This case corresponds to a purely egoistic household (Andreoni 1990). One could alternatively assume that a household's utility depends on both the household's personal contribution

[13] One exception is Brent et al. (2015), who made comparisons across households with the same estimated number of occupants.

to water conservation and the total contributions of all households in the community; in this case, the household would be described as impurely altruistic.[14]

Collective Action toward Utility Costs Savings

There is yet another narrative about how a household might process a SNIT. If a household knows that the utility is selling water to customers below cost and that taxpayers (including the household) end up paying these subsidies, the household may respond to a negative social norms message as follows:

"Since my neighbors are using less water than my household, perhaps I should do my part and reduce my water use. Because the price of water is so low, I'm really using more water than I need, and the utility will save money by not having to produce so much water, and the environment will benefit. If we all do our part, we will all save money because the utility will spend less money and need fewer subsidies, and this will also help the environment. I will benefit because both my taxes and my water bill will be reduced, and I will get to enjoy the environmental benefits."

This is essentially a collective action narrative in which the household recognizes that it is also an owner of the public water utility and perhaps the environmental asset as well, i.e., a household understands that it participates in the benefits of its water reduction as a taxpayer and citizen. One does not need to argue that the household is acting from altruistic motives. In effect, the household does accept that its reduction in water use will result in a net welfare loss (the consumer surplus lost from the reduction in water use), but it sees the bigger picture that it may participate in both the cost savings that accrue to the utility and the benefits to the environment. In this case, the household's welfare loss from reduced water use should be included in the benefit-cost calculation. The cost savings to the household remains a corresponding loss in revenue to the utility, and is thus a transfer payment, but the household will ultimately benefit from the cost savings accruing to the utility, and its loss in consumer surplus may be more than compensated by these cost savings and the environmental benefits.

Hence, there may be considerable heterogeneity in the welfare effects of a SNIT across households. Some households will receive correct information about their water use relative to their neighbors and value this information so that they can better act on their social preferences. Others may receive misinformation and act inappropriately on it,

[14] If the household cares only about the sum of all individual contributions and not about his personal savings, then it is said to be "purely altruistic".

resulting in welfare losses. Some households may understand that they will benefit as taxpayers if the utility sells less water at heavily subsidized prices; others may not.

The welfare effects of a SNIT on households are thus quite difficult to quantify. For purposes of illustration, we use the result of Allcott and Kessler (2015) about the magnitude of the effects of a SNIT on households' welfare. We again assume that a household initially uses 15 cubic meters per month and a SNIT reduces its water use by 3%. Over a one-year period, this household would reduce its water use by 5.4 cubic meters as a result of the SNIT. The average price of water services in low-income countries is around USD 0.30 per cubic meter,[15] so the household's annual cost savings would be about USD 1.6. Following Allcott and Kessler (2015), we estimate the moral costs of the SNIT to be one-half of the cost savings, around USD 0.8 per year. In high-income countries, the average price of water and wastewater services is around USD 4.50, which would lead to annual household cost savings of around USD 24 and moral costs on the order of USD 12 per year.

3.4. Citizens Who Value Improved Environmental Quality

There is a fourth group of stakeholders who may experience a welfare gain as a result of a SNIT. The water utility will need to withdraw a slightly reduced quantity of raw water from the environment. Typically, this water would have come from either surface or groundwater sources, but will remain in the environment as a result of the information treatment, where it may provide ecosystem services and welfare gains to some citizens. The value of additional water for ecosystem services is highly site-specific, and in many cases, may be close to zero.

Another possibility is that reduced municipal water use could "free up" water resources for increased agricultural water use. In this case, there is much more evidence about what water is worth as an input in irrigation (Young and Loomis 2014). A cubic meter of water in modern, high-tech, well-managed irrigation schemes might reach as much as USD 0.25 per cubic meter. In most large irrigation schemes around the world, water is worth far less, only a few US cents per cubic meter.

[15] Average prices for 15 cubic meters (in both developing and industrialized countries) were calculated using data on water tariffs for close to 400 cities surveyed within Global Water Intelligence's 2016 Global Water Tariff Survey. For more details, see: https://www.globalwaterintel.com/global-water-intelligence-magazine/tariff-survey/ (accessed 18 May 2017).

As a starting point for a social benefit-cost analysis of a SNIT, the benefit of not withdrawing a cubic meter from the environment, or alternatively, the value of reallocating the water savings from the SNIT to irrigated agriculture, might be the same order of magnitude as the resource cost savings to the utility on the water side (USD 0.07 per cubic meter). However, this would vary widely by location and in many places would likely be close to zero (e.g., in cities located near large rivers or with large underutilized groundwater reserves).

For purposes of illustration, we assume that the value of leaving a cubic meter of water in the environment is USD 0.07, and that the costs avoided of not putting a cubic meter of treated wastewater back into the environment are also USD 0.07. In some water-scarce locations, treated municipal wastewater actually may have a positive value instead of imposing a cost on the environment. In a low- or middle-income country, a household that initially was using 15 cubic meters per month, which reduces its water use by 3% in response to the SNIT, would thus create a welfare gain for citizens who value environmental quality of roughly USD 0.38 per year [15 cubic meters x 0.03 x 12 months per year x USD 0.07 per cubic meter].

4. An Illustrative Presentation of the Benefits and Costs of a Social Norms Information Treatment

Tables 2 and 3 below summarize the benefits and costs to the three stakeholder groups (owners of the utility, the utility's residential customers, and citizens concerned about ecosystem services) for conditions typical of low/middle-income countries and high-income countries, respectively, assuming the treatment effect of the SNIT lasts one year. As shown in Table 2, our rough calculations suggest that in many cases the cost savings to a water utility in a low-income country from delivering 3% less water will be roughly comparable to the costs of delivering the SNIT, and these cancel each other out in the summation of costs and benefits. The benefit to households of lower water bills is equal to a reduction in the utility's revenues, and this transfer payment also cancels out of the summation of costs and benefits.

We are thus left with two welfare consequences that are largely unknown and likely to be highly site-specific, and, in many cases, quite small. The first is the welfare loss (or gain) that accrues to households in addition to the financial cost savings from the reduction in their water bill. As we have argued, there are several possible narratives regarding this welfare effect. It could be positive or negative. However, it seems most plausible to us that this welfare effect on households is negative (due to both the misinformation effect and the intrusive effect of SNITs) but quite small. For purposes of illustration, in Tables 2 and 3, we assume that the moral costs of the SNIT are half of the costs savings on the household's water bill, as proposed by Allcott and Kessler (2015).

Finally, there is the welfare gain associated with leaving a small amount of water in the environment (or increasing supplies to farmers) on a temporary basis, i.e., until the effect of the information treatment diminishes (which we assume in these calculations is one year).

Table 2. Benefits and Costs of SNIT (in USD Per Household) in Low/Middle-Income Countries (Water Service Only)

Stakeholder (affected party)	Benefits	Costs	Benefits – Costs
1. Utility owners (taxpayers)			
- Cost of social norms information treatment		≈ $1	
- Cost savings from reduced household water use	≈ $1		
- Reduced revenues from households		≈ $1.6	
Net change to utility owners	≈ $1	≈ $2.6	- $1.6
2. Utility customers (households)			
- Reduced water bills	≈ $1.6		
- Moral costs/benefits		≈ $0.8	
Net change to utility customers	≈ $1.6	≈ $0.8	+ $0.8
3. Citizens receiving environmental benefits	≈ $0.38		+ $0.38
Societal Total	≈ $3	≈ $3.4	- $0.4
Benefit-cost ratio ≈ 0.9			

Table 3. Benefits and Costs of SNIT (in USD Per Household) in High-Income Countries (Water & Wastewater Services)

Stakeholder (affected party)	Benefits	Costs	Benefits – Costs
1. Utility owners (taxpayers)			
- Cost of social norms information treatment		≈ $2	
- Cost savings from reduced household water use and wastewater treatment	≈ $3		
- Reduced revenues from households		≈ $24	
Net change to utility owners	≈ $3	≈ $26	- $23
2. Utility customers (households)			
- Reduced water bills	≈ $24		
- Moral costs/benefits		≈$12	
Net change to utility customers	≈ $24	≈$12	+ $12
3. Valuation of environmental benefits	≈$0.76		+ $0.76
Societal Total	≈$28	≈$38	-$10
Benefit-cost ratio ≈ 0.7			

Given our assumptions, the benefit-cost results presented in Tables 2 and 3 show that the SNIT fails a social benefit-cost test in both low and middle-income countries (benefit-cost ratio = 0.9) and in high-income countries (benefit-cost ratio = 0.7). However, our calculations do depend on the assumption that the SNIT imposes a moral cost on a household equal to half the value of the financial cost savings. In low-income countries, this assumption implies a moral cost of the SNIT of USD 0.80 per household. If the moral cost of the SNIT in low-income countries was zero, the benefit-cost ratio of the SNIT would be positive but low (1.15). In high-income countries, this assumption implies a moral cost of the SNIT of USD 12 per household. If the moral cost of the SNIT in high-income countries was zero, the benefit-cost ratio would be slightly positive (1.08).

5. Comparing the Welfare Consequences of a Social Norms Information Treatment and a Price Increase

Water utility managers who want to reduce household water use face a choice between a SNIT and a price increase (of course, they could do both). In this section, we begin with a discussion of the welfare consequences of a price increase in the first year following the increase in a low-income country, using the same assumptions made in the calculations for a SNIT. We discuss the differences between these estimates and those for a SNIT. However, the main advantage of a price increase over a SNIT is that the reduction in water use induced by the increase in tariff will continue beyond the first year. This is because price increases are almost always permanent (i.e., utilities do not usually revert to past, lower prices) and households cannot easily forget about the higher prices as time passes because these increases continue to exert pressure to lower water use. This is in contrast with SNITs, which are commonly implemented either once or over a fixed period of time and have been found to fade away after the treatment stops. Even if the SNIT were to continue indefinitely, we expect that the treatment effect of a SNIT will fade away because households will lose interest and ignore the social norm comparison. In order to compare the welfare consequences of a price increase and a SNIT beyond the first year, we thus calculate the benefit-cost ratio and net present value for the price increase over an assumed five-year planning horizon using a real discount rate of 10%.

For purposes of illustration, we also assume that:

- households respond to average (not marginal) prices;

- the utility uses a uniform volumetric tariff to calculate customers' water bills;

- the price increase results in the same 3% decrease in household water use as the SNIT;

- a 10% increase in prices is required to achieve this 3% decrease in water use (price elasticity of demand of -0.3);[16]

- price of water before the 10% tariff increase (P_0) is USD 0.30 per cubic meter for a low/middle-income country and USD 4.50 per cubic meter for water and sanitation services in a high-income country; so the price of water after the 10% increase (P_1) is USD 0.33 per cubic meter in a low/middle-income country and USD 4.95 per cubic meter in a high-income country;

- total average cost of water supply is USD 1.50 per cubic meter in a low/middle-income country, and the total average cost of both water supply and wastewater collection and treatment is USD 5 per cubic meter in a high-income country;

[16] There exists ample empirical evidence that the price elasticity of residential water demand is of similar magnitude in low/middle- and high-income countries (Nauges and Whittington 2010).

- in both low/middle-income and high-income countries, the representative household used 15 cubic meters of water per month before the tariff increase (Q_0) and 14.55 cubic meters of water per month after the tariff increase (Q_1).

We present the calculations for a low-income country in Table 4, and for a high-income country in Table 5.

5.1. Costs of Implementing a Tariff Increase

As with a SNIT, it is easy to imagine that the costs of implementing a tariff increase are minimal, perhaps just a change in the utility's billing software. However, tariff increases typically require public consultation and information provision. Water bills often must include information explaining the new tariff. For the purposes of this comparison, we assume that the costs of implementing a SNIT and a tariff increase are similar; both require modest real resources for implementation (USD 1 per household in a low-income country and USD 2 per household in a high-income country). We thus assume that there is no significant difference in the upfront cost of implementing a SNIT and a tariff increase.

5.2. Increased Revenues and Cost Savings to Utility

The price increase affects the utility's revenues from a household in two ways. First, the utility receives more revenues from the household for all water sold. The utility receives an extra USD 5.2 per year for Q_1 after the tariff increase (\$0.03 x 14.55 m^3 x 12 months per year). Second, the utility no longer receives USD 1.6 from the household due to the 3% decrease in household water use, i.e., the water the household no longer purchases from the utility [(15 m^3 – 14.55 m^3) x \$0.30 per cubic meter x 12 months per year]. The utility thus receives a net increase in revenues of USD 3.6 per year.

Although the utility loses the revenues associated with the sale of (Q_0 – Q_1) after the price increase, it no longer incurs the costs of producing (Q_0 – Q_1). Because we believe that the effects of a price increase are not temporary, we assume that the utility can achieve the total average cost savings (capital and O&M) by forecasting quantity reductions in its capital improvement planning. The costs savings to the utility from not having to produce (Q_0 – Q_1) are USD 8.1 per year [(15 m^3 – 14.55 m^3) x \$1.50 per cubic meter x 12 months per year). The total benefits to the utility (taxpayers) are thus USD 11.7 per household per year, and the net benefits are USD 10.7 (USD 11.7 minus the USD 1 cost of implementing the tariff increase).

5.3. Households (Customers)

As noted above, after the price increase, the household pays USD 5.2 more for Q_1. The household no longer purchases ($Q_0 – Q_1$), and thus experiences cost savings associated with this reduction in water use of USD 1.6 per year. However, the water no longer used as a result of the price increase ($Q_0 – Q_1$) is more valuable to the household than these cost savings. The household loses the consumer surplus on ($Q_0 – Q_1$), which we estimate as ½ ($P_1 – P_0$) ($Q_0 – Q_1$), equal to USD 0.08 per year. The household thus experiences a welfare loss of USD 5.32 per year as a result of the price increase (USD 5.24 + USD 0.08).[17]

5.4. Citizens Who Value Improved Environmental Quality

By assumption, the two policy instruments yield the same decrease in water quantity and thus the same environmental benefits from reduced water withdrawals in the first year following the price increase. For purposes of illustration, we assume the environmental benefits of the 3% decrease in household water use are the same for the price increase and the SNIT (USD 0.38 per household in year 1). However, the effects of the SNIT last only one year, while those of the price increase continue into the future.

5.5. Results

As shown in Table 4, the illustrative calculations for a water utility in a low-income country show that the societal benefits of a price increase in the first year following the increase are almost twice the costs. However, households in their capacity as utility customers are worse off with a price increase; in the first year after the price increase, they lose both the transfer payment Q_1 x ($P_1 – P_0$) from households to the utility and the forgone consumer surplus ($Q_0 – Q_1$). The benefits to a utility (taxpayers) from a tariff increase in the first year after the price increase are much greater than from a SNIT, both because of the transfer payment from households and (by our assumption) because it

[17] In high-income countries, the utility receives USD 78.6 per year more for Q_1 (\$0.45 x 14.55 m^3 x 12 months per year) but the utility no longer receives USD 24.3 from the household due to the 3% decrease in household water use [(15 m^3 – 14.55 m^3) x \$4.50 per cubic meter x 12 months per year]. The utility thus receives a net increase in revenues of USD 54.3 per year. Moreover, the utility does not incur the costs of producing $Q_0 – Q_1$, a cost savings of USD 27 per year [(15 m^3 – 14.55 m^3) x \$5.0 per cubic meter x 12 months per year). The total benefits to the utility (taxpayers) are thus USD 81.3 per year, and the net benefits are USD 79.3 per year (USD 81.3 minus the USD 2 cost of implementing the tariff increase). The household loses the consumer surplus on ($Q_0 – Q_1$), which we estimate as [½ ($P_1 – P_0$) ($Q_0 – Q_1$)] x 12, equal to USD 1.2 per year.

is possible for the utility to capture the full cost savings on the reduced water use resulting from the price increase.

Table 5 presents similar calculations of the benefits and costs of a price increase in the first year following the increase for a utility and households in a high-income country. As in the previous case of the low-income country, the owners of the utility (taxpayers) receive the vast majority of the benefits in Year 1 (USD 79.3 per household), and the households in their capacity as utility customers incur the costs in Year 1 (USD 79.8 per household). The benefits and costs in Year 1 are approximately the same because in high-income countries households are assumed to pay a price for water that covers 90% of the total average cost of water supply and wastewater treatment, and thus the cost savings on the reduced water produced are much smaller relative to the transfer payment from households to the utility. In contrast, in developing countries, we assume that the price covers only 20% of the total average cost of water, so the cost savings to the utility from the 3% reduction in water produced are much larger relative to the transfer payment from households to the utility. In high-income countries, households pay an extra cost of USD 80 in Year 1 as a result of the price increase, which is roughly three times larger than the utility's cost savings (USD 27). In low- and middle-income countries, households pay an additional cost of USD 5, which is only about two-thirds of the utility's cost savings of USD 8.

Table 4. Benefits and Costs of a 10% Price Increase (in USD Per Household) in Low/Middle-Income Countries (Water Service Only) in the First Year Following the Price Increase

Stakeholder (affected party)	Benefits in Year 1	Costs in Year 1	Benefits – Costs
1. Utility owners (taxpayers)			
- Cost of implementing a tariff reform		≈ $1	
- Cost savings from reduced household water use	≈ $8.1		
- Increased revenues from households	≈ $3.6		
Net change to utility owners	≈ $11.7	≈ $1	$10.7
2. Utility customers (households)			
- Increased payment for Q_1		≈ $5.2	
- Lost consumer surplus on 3% decrease		≈ $0.1	
Net change to utility customers		≈ $5.3	- $5.3
3. Valuation of environmental benefits	≈ $0.4		+ $0.4
Societal Total in Year 1	≈ $12.1	≈ $6.3	+ $5.8

Note: Cost of the tariff increase and the ensuing consequences both assumed to occur in Year 1.

Table 5. Benefits and costs (in USD Per Household) in High-Income Countries (Water & Wastewater Services) in the First Year Following the Price Increase

Stakeholder (affected party)	Benefits in Year 1	Costs in Year 1	Benefits – Costs
1. Utility owners (taxpayers)			
- Cost of implementing a tariff reform		≈ $2	
- Cost savings from reduced household water use and wastewater treatment	≈ $27		
- Increased revenues from households	≈ $54.3		
Net change to utility owners	≈ $81.3	≈ $2	≈ $79.3
2. Utility customers (households)			
- Increased payment for Q_1		≈ $78.6	
- Lost consumer surplus on 3% decrease		≈ $1.2	
Net change to utility customers		≈ $79.8	≈ - $79.8
3. Valuation of environmental benefits	≈$0.8		+ $0.8
Societal Total in Year 1	≈$82.1	≈$81.8	+$0.3

Note: Cost of the tariff increase and the ensuing consequences both assumed to occur in Year 1.

To account for the fact that the consequences of the price increase extend beyond the first year of the planning period, we calculate the benefit-cost ratio and net present value of the price increase assuming the five-year time profile of benefits and costs presented in Tables 6 and 7, for both a low-income and high-income country, respectively. As shown in Table 6, the net present value of the price increase in a low-income country is positive and large, and the benefit-cost ratio (2.2) is much higher than for the SNIT (0.9).

As shown in Table 7, the net present value of a price increase in a high-income country is positive, but small. The benefit-cost ratio (1.02) is higher than for the SNIT (0.7), but close to one. In industrialized countries, given our assumptions, there is not a strong economic case for either a price increase or a SNIT.[18] One advantage of a price increase in an industrialized country is that it increases the financial viability of the utility and may increase productive efficiency (not incorporated in these calculations).

The results presented in Tables 4 and 6 show that households in low/middle-income countries are worse off as a result of the price increase and utility owners are better off, which would appear to suggest that price increases have adverse distributional effects. However, because households are also taxpayers, the equity consequences of the price increase are not easy to sort out, especially if the utility is publicly owned (as is usually the case). The subsidies embedded in current water tariff policies of selling water services below average cost are not well targeted to poor households; most are captured by upper and middle-income classes (Fuente et al. 2016). Thus, the welfare losses to households in their capacity as utility customers do not fall disproportionately on poor households. Moreover, the distributional consequences of the current arrangements for financing the subsidies that the utility receives are site-specific. The price increase reduces the need for these subsidies, and the distributional consequences should not be simply assumed to be negative.

In high-income countries (Tables 5 and 7), a price increase again results in a transfer payment from households to the owners of the utility, but the efficiency gains relative to the size of the transfer are small. Households in aggregate are worse off and owners of utilities are better off. The distribution of the welfare losses among households typically will be hard to determine.

[18] The key assumptions are that the average price is already close to the long-run total average cost and that total average cost is close to long-run marginal cost.

Table 6. Time Profile of Benefits and Costs from a Price Increase (USD Per Household)—Low/Middle Income Country

	Year 1	Year 2	Year 3	Year 4	Year 5	
Benefits	12.1	12.1	12.1	12.1	12.1	Present Value $_B$ = 50.5 USD
Costs	6.3	5.3	5.3	5.3	5.3	Present Value $_C$ = 23.1 USD
						Net Present Value $_{B-C}$ = 27.4 USD Benefit-Cost = 2.2

Table 7. Time Profile of Benefits and Costs from a Price Increase (USD Per Household)—High Income Country

	Year 1	Year 2	Year 3	Year 4	Year 5	
Benefits	82.1	82.1	82.1	82.1	82.1	Present Value $_B$ = 342.4 USD
Costs	81.8	79.8	79.8	79.8	79.8	Present Value $_C$ = 334.8 USD
						Net Present Value $_{B-C}$ = 7.6 USD Benefit-Cost = 1.02

5.6. Sensitivity Analyses

We replicate the calculations of the welfare consequences of a SNIT and a price increase in Year 1, varying several of the key assumptions. The detailed results are presented in the Appendix. Here we summarize the main findings.

Under the extreme assumption that the price elasticity of households' water demand is equal to -1 in both low/middle-income countries and high-income countries, a 3% increase in prices is sufficient to induce a 3% decrease in consumption. In low-income countries, the benefits in Year 1 are three times the costs (Table A1). This is because the utility's cost savings remain unchanged while the burden on households decreases due to the more moderate increase in prices (a 3% instead of a 10% increase). In high-income countries, the extra burden on households decreases compared to the case of a 10% increase in prices, but total benefits in Year 1 remain comparable to the total costs (Table A2).

There is uncertainty about the cost of the SNIT in a high-income country. We thus increased the cost of the SNIT from USD 2 to USD 5. This change implied only a modest decrease in the benefit-cost ratio from 0.74 to 0.68 (Table A3).

Next, we increased the magnitude of the assumed price increase in a low/middle-income country from 10% to 100%. The net benefits per household in Year 1 increase dramatically, from USD 5.6 to USD 56 (Table A4).

Finally, we assume that the reduction in water use due to a price increase only allows a utility in a low-income country to save the same portion of its O&M as a SNIT. In other words, the utility is unable to translate the reduction in water use into deferred capital spending. In this case, the benefits of a price increase in Year 1 (and in subsequent years) are much lower because the cost savings to the utility are much lower (Table A5). In a low-income country, the magnitude and distribution of benefits and costs of the price increase in Year 1 are similar to those associated with a SNIT. In contrast, this assumption has little effect on the magnitude and distribution of benefits and costs of the price increase in Year 1 in a high-income country (Table A6).

6. Concluding Remarks

Despite the widespread and growing popularity of SNITs in the municipal water supply sector, it is far from obvious that these policy instruments will pass a benefit-cost test in a specific locality. The illustrative calculations presented in this paper suggest that water planners should not uncritically advocate for the use of SNITs, especially in low- and middle-income countries where many households are not connected to a sewer network. Instead, they need to do the hard analysis to determine whether a SNIT will be welfare-enhancing in their specific situation.

In most cases, the net benefits of raising water tariffs in a situation typical of many water utilities in developing countries will be greater than the net benefits from SNITs. However, the distribution of benefits and costs associated with a price increase is quite different from a SNIT. The owners of utilities receive most of the benefits from a price increase, and households in their capacity as consumers bear most of the costs. Because most water utilities are publicly owned, taxpayers are the ultimate beneficiaries of the price increase. Since most of the subsidies associated with current municipal water pricing policies are poorly targeted, the ultimate distributional consequences of tariff increases need to be carefully examined. It is certainly possible that in many cases tariff increases will be welfare-enhancing and not exacerbate the already poor distribution of subsidies.

If the welfare consequences of SNITs are unclear, why are they so popular? We suggest that there are three main reasons. First, most water managers are losing money on every cubic meter of water that they deliver, and they perceive that a SNIT will enable them to reduce these losses somewhat. Second, water managers of publicly-owned utilities have little incentive and few skills to tackle the political economy of tariff increases. This task usually falls to the higher-level government authority that is providing the subsidies. Third, the direct cost of the price increase falls on households in their capacity as consumers. Although the distributional consequences of a price increase are unclear, households perceive correctly that they will lose as customers of the water utility, and they are unclear how they might benefit as taxpayers who subsidize the water utility.

SNITs are likely to be most valuable as a temporary tool for reducing water use during droughts. During crisis situations, SNITs may be an easier instrument for utilities to implement than a change in tariffs, which typically requires agreement from other government agencies and political parties. Also, empirical evidence has shown that most reductions in water or energy use occurred quickly after households receive the SNIT. If customers react more quickly to a SNIT than to price increases, then SNITs may be the best solution in response to a temporary drought situation when a quick reduction in water use is required. SNITs may also be preferred to price increases when prices are high (close to the total cost of water supply) and price elasticities are small in magnitude. When demand is inelastic to prices, a larger price increase is needed to induce a reduction in water use. This may impose a large burden on customers, and in particular on those who have low water use and perhaps limited possibilities to reduce it further. However, when utilities aim at a sustained reduction in water use and when prices are still below total average costs, then a comprehensive water tariff reform is the solution utilities should favor. This will not only improve cost recovery but also improve efficiency because prices will move closer to marginal costs. In fact, we suspect that SNITs may distract water managers from the more important challenge of navigating the politics of finding consensus that water tariffs need to be raised in order to increase both allocative and productive efficiency.

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Appendix: Results of Sensitivity Analyses

Benefits and costs of a 3% price increase in the first year following the increase (in USD per household) assuming a price elasticity of demand = -1.0.

Table A1. Low-Income Countries (Water Service Only)

Stakeholder (affected party)	Benefits in Year 1	Costs in Year 1	Benefits – Costs
1. Utility owners (taxpayers)			
- Cost of implementing a tariff reform		≈ $1	
- Cost savings from reduced household water use	≈ $8.1		
- Increased revenues from households	≈ -$0.05		
Net change to utility owners	≈ $8.05	≈ $1	$7.1
2. Utility customers (households)			
- Increased payment for Q_1		≈ $1.6	
- Lost consumer surplus on 3% decrease		≈ $0.02	
Net change to utility customers		≈ $1.6	- $1.6
3. Valuation of environmental benefits	≈ $0.4		+ $0.4
Societal Total in Year 1	≈ $8.45	≈ $2.6	+ $5.85

Table A2. High-Income Countries (Water & Wastewater Services)

Stakeholder (affected party)	Benefits in Year 1	Costs in Year 1	Benefits – Costs
1. Utility owners (taxpayers)			
- Cost of implementing a tariff reform		≈ $2	
- Cost savings from reduced household water use and wastewater treatment	≈ $27		
- Increased revenues from households	≈ -$0.7		
Net change to utility owners	≈ $26.3	≈ $2	≈ $24.3
2. Utility customers (households)			
- Increased payment for Q_1		≈ $23.6	
- Lost consumer surplus on 3% decrease		≈$0.4	
Net change to utility customers		≈$24.0	≈ -$24.0
3. Valuation of environmental benefits	≈$0.8		+ $0.8
Societal Total in Year 1	≈$27.1	≈$26.0	+$1.1

Sensitivity of benefits and costs to the cost of a SNIT—What if the cost of the SNIT in high-income countries is USD 5 per household instead of USD 2 per household?

Table A3. Benefits and Costs of a SNIT in a High-Income Country (Water & Wastewater Services) Assuming SNIT Costs USD 5 Per Household

Stakeholder (affected party)	Benefits	Costs	Benefits – Costs
1. Utility owners (taxpayers)			
- Cost of social norms information treatment		≈ $5	
- Cost savings from reduced household water use and wastewater treatment	≈ $3		
- Reduced revenues from households		≈ $24	
Net change to utility owners	≈ $3	≈ $29	- $26
2. Utility customers (households)			
- Reduced water bills	≈ $24		
- Moral costs/benefits		≈$12	
Net change to utility customers	≈ $24	≈$12	+ $12
3. Valuation of environmental benefits	≈$0.76		+ $0.76
Societal Total	≈$28	≈$41	-$13

Sensitivity of benefits and costs to a larger price increase—What if prices increased 100% in a low or middle-income country?

Table A4. Benefits and Costs of a 100% Price Increase (in USD Per Household) in a Low or Middle-Income Country in Year 1 (Water Service Only)

Stakeholder (affected party)	Benefits in Year 1	Costs in Year 1	Benefits – Costs
1. Utility owners (taxpayers)			
- Cost of implementing a tariff reform		≈ $1	
- Cost savings from reduced hh water use	≈ $81		
- Increased revenues from households	≈ $21.6		
Net change to utility owners	≈ $102.6	≈ $1	$101.6
2. Utility customers (households)			
- Increased payment for Q_1		≈ $37.8	
- Lost consumer surplus on 3% decrease		≈ $8.1	
Net change to utility customers		≈ $45.9	- $45.9
3. Valuation of environmental benefits	≈ $0.4		+ $0.4
Societal Total in Year 1	≈ $103	≈ $46.9	+ $56.1

Note: Assumes price elasticity = -0.3

Sensitivity of benefits and costs to the assumption that costs savings to utility from a price increase are equal to total average costs—What if resource cost savings from a price increase are USD 0.15 per cubic meter in low-income countries and USD 0.50 per cubic meter in high-income countries?

Table A5. Non-Permanent Effect of Price Increase in Low-Income Countries

Stakeholder (affected party)	Benefits in Year 1	Costs in Year 1	Benefits – Costs
1. Utility owners (taxpayers)			
- Cost of implementing a tariff reform		≈ \$1	
- Cost savings from reduced hh water use	≈ \$0.8		
- Increased revenues from households	≈ \$3.6		
Net change to utility owners	≈ \$4.4	≈ \$1	\$3.4
2. Utility customers (households)			
- Increased payment for Q_1		≈ \$5.2	
- Lost consumer surplus on 3% decrease		≈ \$0.1	
Net change to utility customers		≈ \$5.3	- \$5.3
3. Valuation of environmental benefits	≈ \$0.4		+ \$0.4
Societal Total in Year 1	≈ \$4.8	≈ \$6.3	-\$1.5

Table A6. Non-Permanent Effect of Price Increase in High-Income Countries

Stakeholder (affected party)	Benefits in Year 1	Costs in Year 1	Benefits – Costs
1. Utility owners (taxpayers)			
- Cost of implementing a tariff reform		≈ $2	
- Cost savings from reduced household water use and wastewater treatment	≈ $27		
- Increased revenues from households	≈ $54.3		
Net change to utility owners	≈ $81.3	≈ $2	≈ $79.3
2. Utility customers (households)			
- Increased payment for Q_1		≈ $78.6	
- Lost consumer surplus on 3% decrease		≈ $1.2	
Net change to utility customers		≈ $79.8	≈ - $79.8
3. Valuation of environmental benefits	≈$0.8		+ $0.8
Societal Total in Year 1	≈$82.1	≈$81.8	+$0.3