Social Opprobrium and Compliance: Evidence from Water Conservation *

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Abstract

States use mandates as a policy intended to address conflicting incentives for water conservation by water utilities. In this paper, I examine water utility compliance with state-imposed mandates for water conservation during severe drought using data on urban water utilities in California subjected to a year-long mandate. Concurrent with the state mandate, ordinary members of society engaged in opprobrium by "drought shaming" customers engaged in "water waste." I provide evidence that compliance is higher for water utilities where customers actively complain about "water waste." In this context, private citizen activism in the form of social opprobrium appears to be an overlooked aspect of local agency compliance.

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1 Introduction

Decentralized management of water and other natural resources is often promoted as a policy objective because local agencies have better knowledge of their environmental and socio-economic problems than higher-level government institutions (Ostrom, 2000; Kwon, Berry and Feiock, 2009). However, local agencies may make decisions based on short-term objectives that often result in socially inefficient outcomes (e.g., Yaffee, 1997). Consequently, higher-level government institutions (e.g., state, federal, or national governments) intervene to coordinate local actions through centralized, top-down mandates with specific requirements (Brewer and Stern, 2005). Yet, significant implementation gaps arise between legislative objectives and real-world outcomes because local agencies' priorities often diverge from those of higher-level governments (Vig and Kraft, 2012; Burby et al., 2013).[1] In the water sector, these divergent priorities may be further exacerbated due pushback from local agencies' customers.

In this paper, I provide new insights into the dynamics of centralized government mandates using data on urban water utilities in California subject to a drought-related conservation mandate, Executive Order (EO) B-29-15.[2] These data allow me to not only shed light on the extent to which legislative objectives explain conservation outcomes, but also on the role that social opprobrium (reproach or censure) can play during drought. During droughts, water utilities often encourage customers to engage in a form of mutual monitoring by asking them to anonymously report instances in which other customers are using water in ways that are deemed "wasteful," thereby promoting conservation through social pressure. On the one hand, I do not find evidence that requiring water utilities to conserve more water leads to the intended results of higher conservation. On the other hand, I find that the social pressure that end-users exerted upon one another was an important channel through which water utilities conserved water during the mandated conservation period. In this context, customer buy-in in the form of private citizen activism appears to be an important, and perhaps overlooked, aspect of local agency compliance. To my knowledge, this is the first paper to study a mandate in the context of droughts using a framework that accounts for the relationships between local agencies, their customers, and their regulators.

[1] Diverging priorities are especially prominent in the context of planning for natural hazards (Rossi et al., 1982; Cigler, Stiftel and Burby, 1987; Godschalk, Brower and Beatley, 1989).

[2] In the United States, states have the legal authority to establish priorities for how water is used among users at various spatial scales (e.g., Hanemann, Dyckman and Park, 2015)

This study features three novel characteristics. First, EO B-29-15 is the first state mandate for water conservation in the history of California, a state chronically affected by droughts. EO B-29-15 was the first in a series of policy decisions to promote "conservation as a way of life" in California.[3] Learning from California's experience is important given that droughts are expected to increase in intensity, frequency, and duration, especially in regions like California that are already water scarce (Collins et al., 2013).

Second, the design of EO B-29-15 provides an opportunity to study a large number of heterogeneous local agencies faced with different externally imposed incentives to conserve water under a common drought shock. Under this policy, the state of California mandated that all large urban water utilities (serving at least 3,000 residential connections) collectively reduce water production (i.e., conserve water) by 25% from June 2015 through May 2016 (SWRCB, 2015*a*).[4] Typically, a mandate of this nature would take a one-size-fits-all approach, uniformly applying the 25% target to all water utilities. However, the designated state agency—the State Water Resource Control Board (SWRCB)—took a novel approach with EO B-29-15 that lends itself to program evaluation. Each water utility was assigned a different conservation target using a multi-threshold assignment rule based on the average amount of water used by residential users, measured in terms of residential gallons per capita per day (R-GPCD) (SWRCB, 2015*b*). [5] Significantly, water utilities under the California mandate had no direct control over the specific conservation target they were assigned. At each R-GPCD cutoff used to assign conservation targets, water utilities with similar average residential water usage were assigned different conservation targets.[6] This policy, therefore, approximates a random assignment mechanism of conservation targets around the cutoffs. Empirically, I assess the extent to which the mandated targets induced water utilities by exploiting quasi-experimental policy variation in the assignment of conservation targets using a regression discontinuity design. The extent to which the assignment of higher targets led to increased conservation is unclear because there were many cases of both over- and under-compliance. Though urban water utilities collectively reduced water production by 24.5% over the course of

[3] "Making conservation a way of life" is a slogan used by California's Department of Water Resources and State Water Resource Control Board.

[4] Produced water refers to the total amount of potable water from groundwater, surface water, and water purchased from other water utilities. Water that is produced, but not used in a service area, does not count towards the total.

[5] Failure to meet these targets would result in monetary fines.

[6] Water utilities with identical measures of average residential water use may differ in substantive ways (e.g., the mix of single vs multi-family housing). I address this in Section 3.2.1.

the mandated conservation period—just shy of the intended 25% objective—approximately 18% of water utilities subjected to the state mandate reduced water production by more than 10 percentage points above the conservation target assigned to them (over-compliance), while 28% failed to meet their target (under-compliance).

Third, water utilities appear to have successfully used a concurrent widespread, grassroots movement that encouraged citizens to publicly and anonymously shame those who used water in ways deemed wasteful. During the state mandate, ordinary members of society could engage in peer-to-peer opprobrium in the form of "drought shaming," a form of online public shaming where individuals could complain about users "wasting" water. These individuals could take photographs of instances of "water waste" and share these images on online platforms to exert pressure on discretionary outdoor water usage (Milbrandt, 2017). More importantly, the total number of "water waste" complaints that are lodged on these platforms is reported to the state agency and is included in official reports, the primary data set used in this study. This information provides an opportunity to understand the role of social opprobrium in driving behavior. A plausible explanation for this type of behavior is that people who lodge a water waste complaint are likely driven by "nosy" preferences, i.e., preferences that depend on the actions of others (e.g., Danchin et al., 2004; Dave and Dodds, 2012). This mechanism promotes conservation by increasing the social cost of using water for discretionary activities (e.g., lawn maintenance). This explanation is consistent with anecdotal evidence, social media posts, news reports during the study period related to "drought shaming" (e.g., Lovett, 2017), and previous work related to the role of social pressure in overcoming tragedies of the commons (Marco and Goetz, 2017).

My approach builds on previous work that examines decentralized management through the lens of principal-agent theory (Jensen and Vestergaard, 2001; Tommasi and Weinschelbaum, 2007; Estache, Garsous and da Motta, 2016). Moral hazard arises in situations where agents are unwilling to undertake costly unobservable actions (henceforth referred to as effort) to cooperate with the principal (e.g., Stiglitz, 1974). A moral hazard framework is particularly useful to understand compliance with EO B-29-15 because mandated objectives implemented by a higher-level government require that water utilities cooperate by implementing conservation measures to achieve desired water conservation objectives. The financial and implementational onus of monitoring and enforcement is borne by the water utilities, with little to no help from the state. Water utilities must therefore trade off the costs and benefits of complying with the mandate. Using principal-agent theory, mandating conservation targets can be thought of as an attempt by higher-level governments (principal) to vertically align water utilities' (agents) incentives with their own by "contracting" with them based on conservation outcomes. Since each utility was responsible for managing demand among their residential customers, water utilities' compliance is a function of their own principal-agent problem because water utlities (principal) must convince their customers (agents) to reduce water use in order to achieve their assigned targets.

This paper contributes to the literature on water demand, which has explored households' extrinsic and intrinsic motivations to conserve. Studies on extrinsic motivations have explored household responses to demand-side management (DSM) strategies (e.g., rebates for turf replacement or water efficient fixtures, mandatory watering restrictions, or pricing strategies) (e.g., Nataraj and Hanemann, 2011; Mansur and Olmstead, 2012; Baerenklau, Schwabe and Dinar, 2014; Klaiber et al., 2014; Wichman, Taylor and Von Haefen, 2016; Browne, Gazze and Greenstone, 2019; El-Khattabi et al., 2020). Studies on intrinsic motivations have pointed to behavior driven by a sense of "warm glow" in which people conserve out of a sense of environmental responsibility or a desire to feel good about their own contribution to a public good (e.g., Van Der Linden, 2015). These studies include the evaluation of behavioral interventions (e.g., nudges) that rely on intrinsic motivation to drive reductions in water usage (e.g., Allcott, 2011; Bernedo, Ferraro and Price, 2014; Brent, Cook and Olsen, 2016). To my knowledge, this literature does not explore peer-to-peer influence, such as "nosy" preferences or social opprobrium, which has shown to have an effect in the sanitation literature (e.g., Guiteras et al., 2016) and in environmental conservation efforts (e.g., Cisneros, Zhou and Börner, 2015).

This paper also contributes to several other bodies of work, including public economics (e.g., Buchanan, 1978), public administration (e.g., Thomas, 2013; Nabatchi and Amsler, 2014; Bovaird et al., 2015; Sicilia et al., 2016), and urban planning (e.g., Jacobs, 1961) by shedding further light on the role of customer buy-in that aims to engage individuals as partners in achieving policy objectives. In these works, scholars argue that individuals are more likely to engage in moral or ethical acts when the community is involved in monitoring behavior. The idea that individuals act more ethically when there is fear of shame from the community can be applied to this context in which individuals engaged in "drought shaming" to help promote conservation. The results of this study highlight that compliance with mandates was easier in services areas where individuals helped promote social norms to promote conservation by monitoring their peers. In this light, the lessons learned from studying the role of customer-driven complaints during California's drought could be generalized to any context where compliance with mandated requirements may be supported by the promulgation of social norms through opprobrium and mutual monitoring from the general public.

2 Conceptual Framework

2.1 Water Utility Incentives for Water Conservation

In response to a drought, water utilities can either promote conservation or increase water capacity. With respect to conservation, water utilities face conflicting incentives. Water utilities face disincentives to voluntarily engage in conservation. Increased conservation implies reduced revenue as less water is sold, putting financial pressures on water utilities that may be financially insecure (Kenney, Klein and Clark, 2004). The total amount of forgone net revenue due to conservation during EO B-29-15 is estimated to have been more than $500 million (Moss et al., 2015). Moreover, pursuing conservation may be met with social pressure and have political consequences. Commercial customers may oppose conservation as it may be perceived as being at odds with economic growth and development. In the residential sector, customers may resist restrictions on water usage because of either strong preferences for lush green lawns or a perceived threat to lifestyles (Brown and Hess, 2017).

Conversely, water utilities have incentives to voluntarily pursue conservation when water resources are scarce. For instance, water utilities often pursue conservation as drought condition worsen to ensure continuity of service and prevent supplies falling below minimum reserve levels. Water utilities may also choose conservation strategies over capacity increases in reponse to pressure from other water utilities and stakeholders to reduce withdrawals from shared water supply sources. Incentives to conserve may outweigh the potential political costs of pursuing conservation. For instance, Mullin (2009) shows that water utilities in Texas adopted water usage restrictions despite strong political resistance to any policies that restrict water use.

Incentives to increase capacity are often stronger than those to pursue conservation (Chesnutt and Beecher, 1998). Severe droughts may prompt increased interest in reducing non-revenue water (water losses due to leaks), interest in water-sharing agreements (Zeff et al., 2016; Mozenter et al., 2018; Gold et al., 2019; Gorelick et al., 2019), and investments in water recycling and reuse, rainwater and stormwater harvesting, and desalination.[7] Supply-side measures, however, may do little to alleviate short-term constraints as they involve projects that are typically less flexible and longer-term in nature. Moreover, a collective action problem may arise among water utilities sharing water resources. For instance, water utilities may increase withdrawals from shared water supply sources, or excessively withdraw groundwater supplies during droughts, because resource scarcity may reduce incentives to cooperate and exacerbate tendencies to act on short-term incentives by adopting a "race to the bottom for extraction-profit" strategy (Maldonado and del Pilar Moreno-Sanchez, 2016).

From the SWRCB's perspective, water utilities may not be sufficiently motivated to aggressively conserve water during droughts. Though water utilities want to avoid running out of water, water utility managers are also sensitive to social and political pressures exerted by their customers against aggressively pursuing conservation (Dalton and Burby, 1994; Mullin, 2009; Teodoro, Zhang and Switzer, 2018). Due to this pressure, water utility managers often delay pursuing conservation as long as possible (Walker, Hrezo and Haley, 1991), "weigh[ing] the risks of delay against potential public relations problems" (TCEQ, 2005). In contrast, state governments are not subject to the same local pressure. Moreover, state governments have a clearer stake in reducing the risks of drought because they may bear a significant share of the economic costs if droughts are not mitigated, including the costs of disaster assistance (Schwab et al., 1998; Wilhite, 2000).[8] Unable to perfectly control or monitor local water utilities, state governments need the cooperation of local-water utilities to achieve desired policy objectives (i.e., water conservation).

2.2 Institutional Setup

State mandates, such as the one adopted by the SWRCB, promote conservation through two mechanisms: (1) increasing the political acceptance of local conservation efforts by shifting some of the responsibility from local water utilities to the state agency, and (2) enforcement through a

[7]The Australian government, for instance, invested billions of dollars in alternative water sources such as recycling and desalination to diversify their water supply portfolio during the "millennium drought" (Radcliffe, 2015).

[8]The National Centers for Environmental Information estimates that the average economic cost that a typical drought episode incurs is approximately $9.5 billion (NCEI, 2020).

coercive regulatory approach consisting of a threat of monetary fines and legal action against the water utility as punishment mechanisms for noncompliance.[9]

The institutional setup of California's EO B-29-15, shown in Figure 1, consists of three main actors: the designated state agency (SWRCB) responsible for carrying out the state mandate, water utilities subject to the mandate, and residential customers (end-users). Each of these actors could take actions, represented by downward arrows. For instance, the SWRCB mandated conservation targets and water utilities could engage in water conservation by adopting one or more DSM and are able to enforce these strategies through fines. Upward arrows represent expected outcomes. In particular, end users can conserve (or not) which, in turn, effects water utilities conservation outcomes.

The SWRCB monitored water utilities' progress with their assigned target by tracking water utilities' total monthly potable water production levels.[10] The SWRCB sent monthly warning letters to water utilities between 1-5 percentage points below their assigned target, and notices of violations to those more than 5 percentage points below their assigned target.[11] Water utilities' performance was ultimately judged at the end of the mandate in May 2016. The exact nature of the penalty for failing to be in compliance with the mandate depended on the size of the implementation gap, ranging from providing the SWRCB with further information documenting their effort to in person meetings.

Given the institutional setup of the mandate, my approach builds on previous work that examines decentralized management through principal-agent theory. Principal-agent models have been widely used to study situations in which two parties with differing incentives depend on each other to achieve objectives. Specifically, one party, the agent, acts on behalf of the second party, the principal, in a context in which the principal usually cannot perfectly monitor the agent.

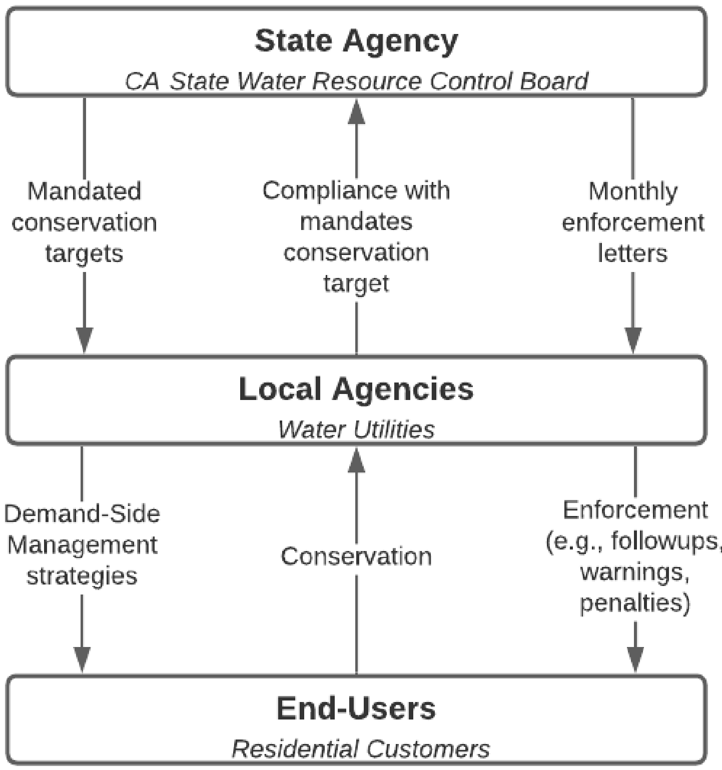
Moral hazard arises from conditions stemming from asymmetric information. First, it is often difficult to observe water utilities' actions. In an effort to mitigate this problem, the SWRCB

[9]This characterization is based on May and Williams's (2012) conceptual framework of state approaches for managing natural hazard risks. See Berke et al. (2006) and Dyckman (2016) for reviews on how state mandates are characterized.

[10]Potable water production is defined as the sum of water extracted from groundwater and surface water sources and treated water purchased from another water system. Water that was produced by water supplier but not used in the water service area did not count towards the total.

[11]Water utilities who were within 1 percentage point or that had production savings in excess of their target received notices of congratulations.

Figure 1: Illustration of Institutional Setup



Notes: Downward arrows represent actions that each represented actor can take. Upward arrows represent expected outcomes.

required water utilities to generate monthly reports with several key pieces of information as part of the mandate. In these reports, the primary data source used in this study, water utilities were required to report information on water production levels in each month, the number of days in the week that their customers could water outdoor landscapes and the number of actions taken to enforce their policies (e.g., number of warnings and citations issued to customers). However, water utilities were not required to report on other specific DSM policies that they used. Because of this difficulty, it is challenging to distinguish water utilities that try to comply with the mandate but simply miss the mark from those that don't try to comply.

Second, even if all actions taken by the water utility were observable, they may not be easily interpreted because different water utilities may implement the same strategy with varying degrees of "implementational intensity" (Halich and Stephenson, 2009). For instance, it is often the case that a water utility will adopt a DSM strategy but either not enforce it. Moreover, there continues to be significant disagreement over the relative effectiveness of prices, usage restrictions, and other DSMs in promoting conservation in spite of the substantial literature on this topic (e.g., Renwick and Green, 2000; Polebitski and Palmer, 2013; Olmstead and Stavins, 2009; Mini, Hogue and Pincetl, 2014; Maggioni, 2015; Wichman, Taylor and Von Haefen, 2016).

Lastly, enforcing the “contract” based on conservation outcomes alone presents an issue for the SWRCB because water utilities’ ability to conserve depends on end-users (i.e., customers). In other words, there is a second principal-agent problem. In this second principal-agent problem, water utilities (principal) must rely on their customers (agents) to reduce their water consumption to achieve desired outcomes, potentially undertaking costly and unobservable actions to do so. Water utilities observe household water usage and can, in turn, “contract” with their customers on outcomes, enforcing their policies in the event of non-compliance. Furthermore, there may be multiple types of customers, some who may be easily encouraged to comply and others who might not. The two-part nature of the problem presents a challenge for the SWRCB because the level of effort that a water utility must exert will depend on characteristics of its customer base that the SWRCB may not observe.

In this context, there are three possible explanations for implementation gaps. First, it is possible that local agencies may be willing but unable to comply with mandated requirements. Notably, many water utilities struggle financially due to insufficient revenues or do not have the requisite staffing capacity to enforce policies (Faguet, 2014). Second, implementation gaps may arise because local agencies may be unwilling to comply with mandated requirements due to diverging priorities (Vig and Kraft, 2012; Burby et al., 2013). Third, implementation gaps may also arise if the state is unwilling to enforce regulations and hold local agencies accountable for failing to meet mandated objectives (Berke, 1998; May and Williams, 2012). In other words, though the state can observe and contract upon outcomes, it is often reluctant to do so as enforcement would likely result in lengthy and costly legal action that the state agency would prefer to avoid.[12]

[12]See SWRCB (2015*c*) for an example of formal legal action against water utilities for failing to comply with their mandated conservation target.

2.3 Household Incentives

There are two main channels through which residential households may be encouraged to conserve: intrinsic and extrinsic motivation. Households who are intrinsically motivated may be driven by a sense of environmental responsibility, i.e., warm glow, would reduce their own consumption to feel good about their own contribution (De Young, 1985; Corral-Verdugo et al., 2002). To encourage these end-users, water utilities rely on public awareness campaigns to spread awareness and the need for conservation. Examples of awareness campaigns include ads on radio and/or TV, sending out flyers, hanging up banners, or sending staff to engage with private citizens at farmer's markets. Previous studies have shown that receiving information about drought conditions plays an important role in promoting household conservation (Tang et al., 2015; Quesnel and Ajami, 2017).

Some customers may not only be intrinsically motivated to reduce their own water consumption but may be driven by "nosy" preferences, i.e., preferences that depend on other customers' actions (e.g., Danchin et al., 2004; Dave and Dodds, 2012). Customers with these preferences may be outraged over "water waste" (a perceived moral norm violation) and express their preferences through overt opprobrium or through anonymous online reports. Moreover, availability of digital media platforms and anonymous reporting mechanisms can amplify the the expression of moral outrage in part by reducing individual-level costs (Crockett, 2017). In the context of water conservation, harnessing this outrage may provide an opportunity for citizens with "nosy" preferences to be part of the enforcement process.

Extrinsically motivated households may conserve water in response to external reward mechanisms such as monetary incentives. Water utilities encourage these customers to conserve through DSMs, such as increased prices or rebates to adopt new technologies. These households may also be sensitive to the enforcement of water utility policies such as warnings or penalties. Household responses to enforcement efforts may vary depending on the credibility of the threat, the probability of enforcement, and the size of the penalty. Moreover, these households may also be sensitive to other external reward mechanisms, such as shame or social opprobrium exerted by their peers with "nosy" preferences. Notably, shaming particular uses of water during a drought effectively represents an increase in the social cost of discretionary water usage.

Do "nosy" preferences matter for conservation? If households are not sensitive to opporbrium by their peers with "nosy" preferences, the amount of public reporting of "water waste" should not make a difference for the amount of conservation. If "nosy" preferences do matter, increased public reporting of "water waste" should result in higher levels of conservation.

3 Data

The SWRCB dataset consists of information for all 393 retail water utilities serving at least 3,000 residential connections that are subject to the mandate. Of these, three water utilities are excluded because they received exemptions from initial conservation target were granted. The dataset includes each water utility's primary water system identifier (PWSID) assigned by U.S. Environmental Protection Agency's Safe Drinking Water Information System, monthly self-reported water production, average residential usage, 2013 water production levels, assigned conservation target, and an estimate of the number of residential customers. The dataset also contains information on the number of reported cases of "water waste" complaints by the general public and information on enforcement as well as an optional comment section containing additional information related to enforcement.

I supplement these data with information from several additional sources, including water utility's urban water management plans submitted to California's Department of Water Resources (CA DWR) in 2015, information from U.S. Environmental Protection Agency's Safe Drinking Water Information System (SDWIS), and California's Public Utilities Commission to capture water utility characteristics that may influence water utilities' incentive to pursue conservation. These factors include their primary water source, exposure to severe drought conditions, and factors associated with taking on political risk. I also obtain spatial boundaries for each water utility in the SWRCB dataset from CA DWR.[13]

3.1 Data from State Water Resource Control Board Reports

3.1.1 Conservation Targets

To induce water conservation, the SWRCB created a tier-based list of conservation targets based on specific ranges of average residential gallons per capita per day (R-GPCD) during July – September 2014 (SWRCB, 2015b). R-GPCD is calculated as total water sold to the residential sector divided

[13] Of the 390 water utilities in the SWRCB dataset, 11 agencies did not submit urban water management plans to the CA DWR. Only two of the 11 agencies were not required to submit an urban water management plan.

by the service area population. This approach has been commonly used to measure efficiency in previous conservation efforts (e.g., CA Water Conservation Act 2009) and is also the basis for current policies (Quinn, 2012). Based on these R-GPCD ranges, each urban water utility in the state was assigned a conservation target that ranged between 8% and 36%.

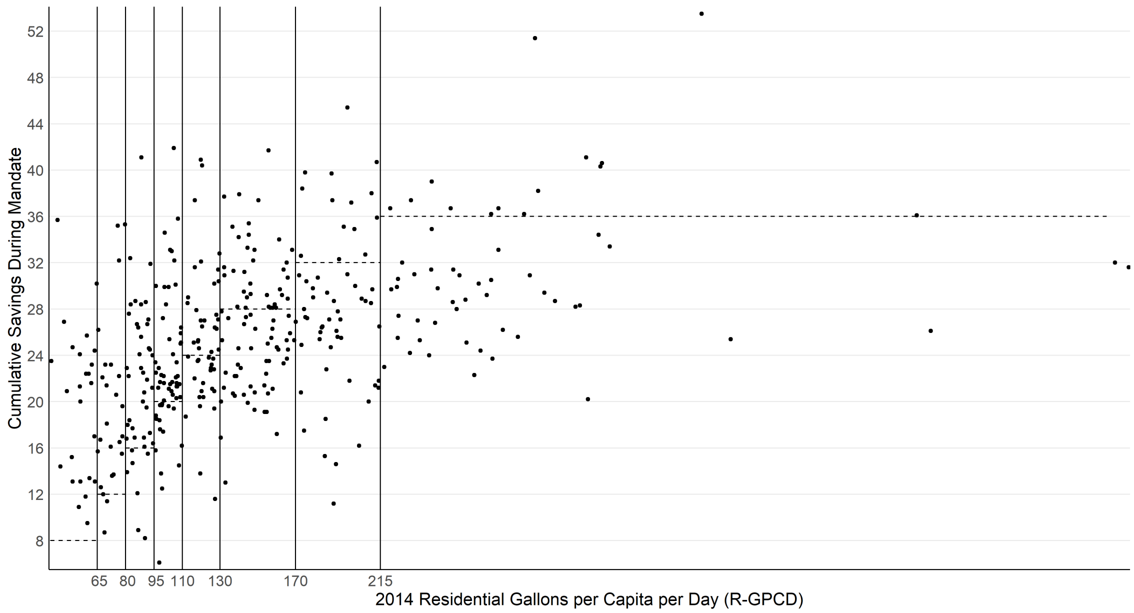
The rule that the SWRCB used to assign conservation targets can be expressed by the following piecewise function, $S(d_i)$, where the variable d_i represents water utility i's R-GPCD in the summer of 2014:

$$S(d_i) = \begin{cases} 8\%, & 0 < d_i < 65, \\ 12\%, & 65 \leq d_i < 80, \\ 16\%, & 80 \leq d_i < 95, \\ 20\%, & 95 \leq d_i < 110, \\ 24\%, & 110 \leq d_i < 130, \\ 28\%, & 130 \leq d_i < 170, \\ 32\%, & 170 \leq d_i < 215, \\ 36\%, & 215 \leq d_i \end{cases}$$

These targets represent conservation objectives defined as percent reduction in water production relative to 2013 levels and were judged on a cumulative basis from June 2015 through the end of the mandatory conservation period. Specifically, the SWRCB compared the sum of monthly water consumption starting June 2015 to the sum of corresponding months of 2013 (SWRCB 2015a). Water utilities that met the adjusted conservation standard were considered compliant. As shown in Figure 2, water utilities with higher 2014 R-GPCDs generally conserved more water but differences in the amount of conservation around the established cutoffs is unclear.

As shown in Panel A of Table 1, the mean cumulative water production savings over the

Figure 2: Conservation Outcomes



Notes: Points represent water utilities' conservation outcomes given their residential gallons per capita per day (R-GPCD) in the summer of 2014. Vertical lines represent the cutoffs established by the SWRCB. Dashed horizontal lines represent the minimum percent conservation water utilities were expected to achieve.

entire period was 25.5% with a standard deviation of 7.2%.[14] All of the water utilities in the sample reported at least 6.0% savings by the end of the mandatory conservation period, with a maximum savings of 45.4%. Conservation was not uniformly achieved relative to the assigned conservation targets. Though water utilities with higher conservation targets achieved greater conservation levels, they were also generally less successful in meeting their targets than those with lower targets. As shown in Panel B of Table 1, only 281 utilities (72%) met or were within one percentage point of their conservation standard (SWRCB, 2016c).

[14]Aggregate conservation is not necessarily the same as mean conservation:

$$\frac{\sum_i^N X_i^{2015} - \sum_i^N X_i^{2013}}{\sum_i^N X_i^{2013}} \neq 1/n \sum_i^N \left(\frac{X_i^{2015} - X_i^{2013}}{X_i^{2013}}\right)$$

Table 1: Descriptive Statistics

Panel A: Conservation relative to assigned conservation targets

2014 R-GPCD	**Assigned Target**	**Cumulative** *Mean (%)*	*Std.*	**Relative to Target** *Mean (%)*	*Std.*	**Water Utilities**	**Met Target**
0-65	8%	19.94	6.58	11.94	6.57	25	100.00%
65-80	12%	19.53	7.13	9.57	7.26	24	95.83%
80-95	16%	21.96	6.56	7.52	6.05	41	92.68%
95-110	20%	22.87	6.13	5.73	6.79	57	77.19%
110-130	24%	25.43	5.76	3.65	5.83	46	76.09%
130-170	28%	26.79	5.44	2.09	5.58	83	66.26%
170-215	32%	28.13	6.97	-0.65	6.89	57	50.87%
215+	36%	31.21	6.44	-1.36	6.88	57	33.33%
Total		25.51	7.17	3.56	7.49	390	68.71%

Panel B: Compliance with assigned conservation targets

	Number of Water Utilities	**Percent of Water Utilities**
Failed to meet conservation standard by more than 10 percentage points	12	3%
Failed to meet conservation standard by 1 - 10 percentage points	97	25%
Met conservation standard by +/- 1 percentage point	35	9%
Exceeded conservation standard by 1 - 10 percentage points	177	45%
Exceeded conservation standard by more than 10 percentage points	69	18%
Total	390	100%

3.1.2 Complaints Reported by the General Public

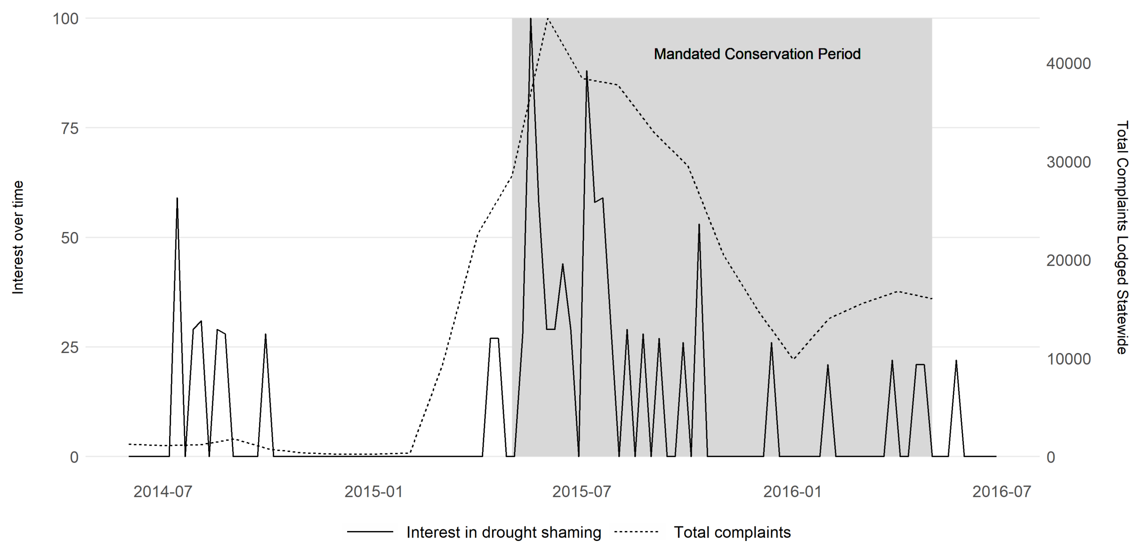
Throughout the drought, private citizens (customers and the public at large) were asked to be the "eyes and ears of the community" by anonymously reporting instances of leaks, sightings of water running down the street, sprinklers on during the middle of the day, or other potential instances of "water waste" (e.g., Glendale Water and Power). In the year prior to the mandate (2014-2015), people driven by nosy preferences began expressing their outrage through "drought shaming." People engaging in this type of public shaming took pictures of visible instances of "water waste" and posted them on online platforms (e.g., Twitter with the hashtag #droughtshame or #droughtshaming). Though many instances of "drought shaming" consisted of pictures where trace amounts of trickled onto pavements, most instances of "drought shaming" are attributable to specific individuals, such as neighbors or other residents (e.g., Lovett, 2017).

The state set up an online portal, often referred to in the media as a "drought shaming" platform, where customers could report instances of water waste without knowing the name of the local water utility or how to contact them.[15] The only information required to lodge a complaint is the nature of the observed "water waste" and the address at which it is observed. There is also an option of attaching pictures. Water utilities are then able to search for their service area and then follow up on these complaints. In addition to the statewide portal, many water utilities have their own local hotlines and portals. Most reported instances of water waste were reported directly to the statewide portal. In Figure 3, I plot a measure of interest in "drought shaming" obtained from Google Trends alongside the number of complaints in the data; the two series are highly correlated. Of note, the "drought shaming" search term is exclusively popular in California, primarily in the San-Francisco-Oakland-San Jose, San Diego, and Los Angles metro areas.

As part of their reporting to the SWRCB, water utilities were required to log the number of publicly reported cases in their monthly reports to the SWRCB, referred to in the dataset as *complaints received*. I use this information to construct a measure of relative private citizen involvement in the enforcement process. Using the number of complaints received during months before the mandate was implemented, I identify a water utility's customer base as having a high degree of "nosy" preferences if the total number of complaints per capita received is above the median, and low otherwise. To shed some light on what characteristics may be associated with

[15] The state portal for reporting instances water waste can be accessed at https://savewater.ca.gov/.

Figure 3: Interest in "Drought Shaming"



Notes: The shaded area represents the year in which EO B-29-15 was in effect (mandatory conservation period), the dashed line represents the total number of reported water waste complaints, and the solid line represents interest in "drought shaming" obtained from Google Trends. A score of 100 represents peak popularity for "drought shaming" search term. Scores of 0 indicate that there is not enough data.

"nosy" preferences, I provide summary statistics on service area characteristics by level of "nosy" preferences in Appendix A. Service areas differing in the degree of "nosy" preferences do not seem to vary substantially along any particular dimension.

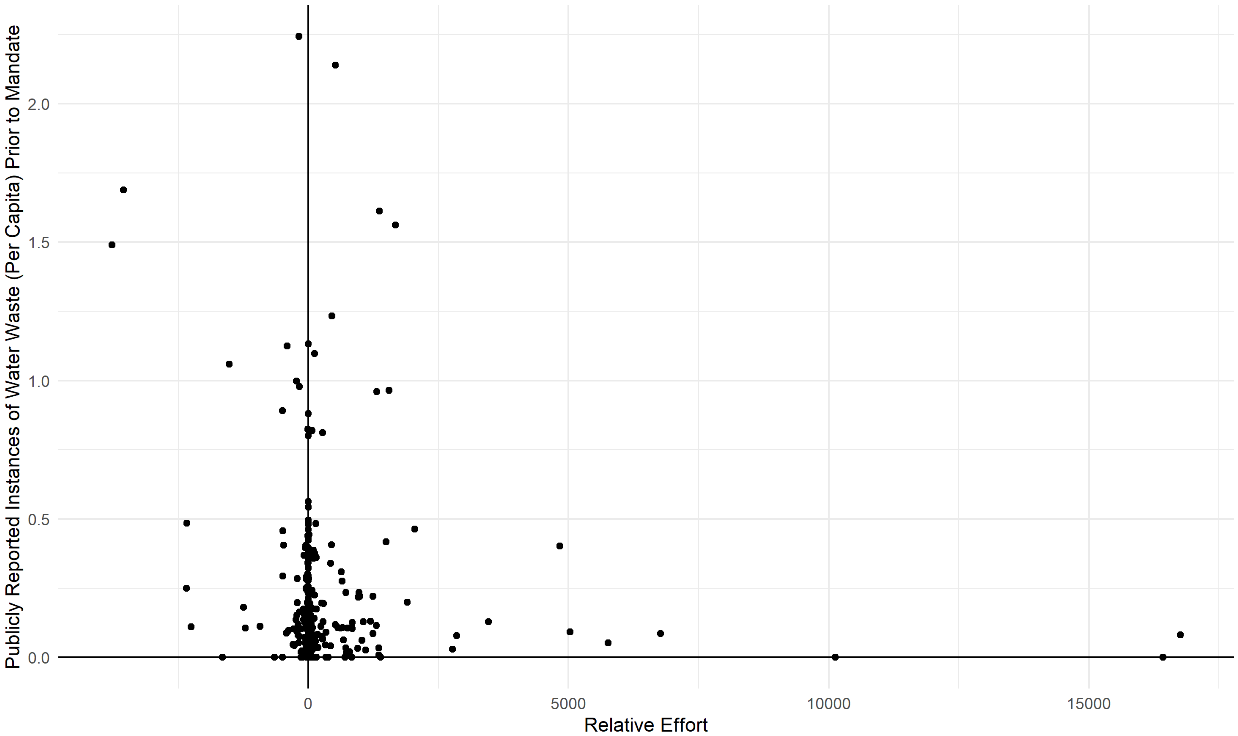
3.1.3 Water Utility Enforcement

Water utilities reported several metrics related to how intensely they implemented their policies. First, they reported on the total number of reported cases they followed up on, referred to in the dataset as follow-ups. The number of follow-ups includes both cases that were reported by private citizens—*complaints received*—from hotlines or online portals in addition to cases reported by water utility staff. Water utilities also reported on the number of warnings issued to violators as well as the number of penalties issued, referred to in the dataset respectively as *warnings* and *penalties*. Water utilities were also required to report the number of drought-surcharge penalties issued, referred to as *rate penalties*.

In reading the optional enforcement comments, it is evident that water utilities define and report information on *warnings*, *penalties*, and *rate penalties* differently from each other. Namely, several definitions of *rate penalties* emerge. Some utilities define these as surcharges associated with usage in higher tiered rates, hence as temporary per-unit charges that effectively act as price increases. Others issue rate penalties for exceeding a usage target or water budget allowance, overlapping in definition with *penalties*. For example, representatives of San Jose Water described their use of rate penalties in an interview as not being "a rate increase, but a penalty program to encourage conservation" (Rogers, 2017). Others note that they did not "issue fines or penalties in the legal sense of those terms," but functionally did the same by charging a drought surcharge. It is also the case that there are inconsistencies in which field water utilities record this information month-to-month; the same water utility would often record *penalties* as *rate penalties* in one month and the reverse in other months. Similarly, some water utilities defined *warnings* in ways that overlapped with *follow-ups* or with *penalties*. Additionally, water utilities often neglected to record information in certain months. In most of these instances, water utilities would record both the information that was not previously reported along with new information together as one entry in subsequent months.

Given the issues in measuring the number of *warnings* and *penalties*, I define effort in terms of the number of *follow-ups*. Zhang and Teodoro (2018) argue that *follow-ups* reflect the degree to which water utilities convey information about their policies. Building on this argument, I argue that they also reflect the degree to which water utilities exert effort because they capture instances in which water utilities actively seek out cases of water waste. Assuming the number of public complaints is a lower-bound for the number of instances of water waste, water utilities taking a more passive approach might only rely on public complaints of water waste or might not follow-up on all the cases that were reported by the public. Water utilities taking a more active role towards enforcement would theoretically follow-up on more cases than were reported. To address this, I construct a measure of relative effort, identifying a water utility as exerting *High* effort if the difference between *follow-ups* and *complaints received* is positive and *Low* effort otherwise. In Figure 4, I plot the relationship between complaints received per capita relative to the number of cases followed up on by water utilities.

Figure 4: "Nosy" preferences vs. the number of cases followed up by water utilities



Notes: Relative effort is defined as the difference between *follow-ups* and *complaints received*.

3.2 Data from Urban Water Supply Plans

3.2.1 Residential Gallons Per Capita Per Day

The SWRCB assigned conservation targets based on R-GPCD. This assignment rule assumes that water utilities with similar R-GPCDs are similar. It may be possible, however, for two water utilities with similar R-GPCDs to differ in the proportion of water that is used by their single family customers versus multifamily residential customers. This difference could impact a water utility's ability to conserve. In comparing usage characteristics by sector (single family residential, multi-family residential, commercial, other) for five water utilities subject to EO B-29-15, Gaur, Smith and Kostiuk (2019) find that usage among single family households generally reduced while water usage in other sectors (including multifamily residential water usage) remained generally uniform. I use information from each water utility's urban water management plans submitted to the DWR in 2015 to calculate the percentage of residential water usage that is single family to control for differences between service areas with similar measures of R-GPCD.

3.2.2 Groundwater Source

Water utilities differ in where they obtain their water sources from. The natural resources management literature would suggest that water utilities that are more dependent on ground water sources would have less incentive to conserve because groundwater is cheap to extract and information regarding the amount of groundwater that is available is scarce (Madani and Dinar, 2012). Additionally, drought plans generally give limited attention to long-term management of groundwater sources (Langridge et al., 2018). In California, legislation for groundwater management was signed in 2014. Most of the implementation deadlines, however, went into effect after EO B-29-15. I obtain information on water utilities' primary water source from U.S. Environmental Protection Agency's Safe Drinking Water Information System.

3.2.3 Investor-Owned Water Utilities

Lastly, the propensity for local agencies to take on political risk depends on local sociopolitical context (West, Lee and Feiock, 1992). Notably, the ownership structure of the water utility may influence its decisions to take on political risk. For instance, investor owned-utilities may be more sensitive to lost revenue than a public water utility. Investor-owned water utilities, however, are regulated by California's Public Utilities Commission (CPUC) and have decoupled rates. This mechanism enables them to recover any forgone revenue due to conservation. Teodoro, Zhang and Switzer (2018) further argue that regulation via the CPUC provides a type of political decoupling, insulating investor-owned utilities from some of the political pressures that public utilities may face as a result of being directly accountable to voters. Also using data on EO B-29-15, Teodoro, Zhang and Switzer (2018) find evidence that investor-owned water utilities were more likely to reduce water production more than public water utilities during the mandate. I identify investor-owned water utilities using a list of the water utilities regulated by California's Public Utilities Commission (CPUC).

3.2.4 Regional Planning

Higher-level governments often encourage horizontal coordination among local agencies to promote regional collaboration (Burby et al., 1997). Horizontal coordination is meant to improve resource planning by increasing local capacity and by aligning incentives among neighboring agencies that share resources. In the context of water management, horizontal coordination could also be a tool to mitigate over-withdrawing shared water supplies. Though horizontal coordination was not mandated as part of EO B 29-15, water utilities are encouraged to collaborate with "other water suppliers that share a common [water] source, water management agencies, and relevant public agencies, to the extent practicable" (DWR, 2015). To investigate the effect of horizontal coordination, I control for whether or not a water utility's urban water supply plan was submitted as part of a regional partnership.

3.3 Drought Conditions

Drought conditions vary by geography. Some water utility service areas may have experienced severe drought conditions for longer periods of time than other service areas with the same assigned conservation target. To account for this potential difference, I further supplement the SWRCB dataset with information on drought conditions using data obtained from the National Oceanic and Atmospheric Administration (NOAA). Drought severity is measured using Palmer Drought Severity Index (PSDI), a measure of relative dryness based on a physical water-balance model.

4 Estimation

I examine the effectiveness of the assigned conservation targets on reductions in water production using a sharp regression discontinuity design. This approach estimates the effect produced solely by the assigned target by exploiting discontinuities in cutoffs used to assign treatment. A key feature of regression discontinuity design is the existence of a score that determines treatment assignment for each unit in the sample given a cutoff score. Units with scores above the cutoff score are considered "treated," while units whose score is below the cutoff are not. As discussed in Section 2.1, the SWRCB assigned conservation targets using an assignment rule based on R-GPCD during the summer of 2014.

A potential threat to validity would arise if water utilities were able to self-select into particular cutoffs by manipulating their July-August 2014 R-GPCD. This is unlikely to have been the case for two inter-related reasons. First, EO-29-15 is the first mandate in California's history and its structure is different from mandates used in other states to manage drought. Therefore, it is unlikely that water utility in 2014 knew that a mandate would be issued in 2015 or how it would be designed. Second, cutoffs based on 2014 R-GPCD were devised after the announcement of the mandate in 2015. Following the proclamation of EO-29-15 in April, 2015, there were several weeks of public comments. These comments were used by the SWRCB in formulating the regulations that were officially adopted at the SWRCB's May 5th meeting. Water utilities, therefore, could not have influenced their R-GPCD during July-August 2014 in direct anticipation of the mandate. Even if water utilities had some influence over the assignment variable, their inability to precisely manipulate it is sufficient to assume that variation in treatment near the threshold is random (Lee and Lemieux, 2010). An important feature of the assignment mechanism used by the SWRCB is that it essentially generates a random assignment of the treatment among utilities around the cutoffs. From the perspective of the SWRCB, the choice to assign two water utilities with near identical R-GPCD different conservation targets is arbitrary.

A common practice in the literature estimating regression discontinuity designs with multiple cutoffs is to estimate a pooled regression using a normalized running variable. Following this approach, I estimate the effect of receiving a higher conservation target by comparing water utilities with a higher target (treated) to similar water utilities that received lower targets (control). The local average treatment effect (LATE) is given by:

$$\hat{\tau} = \lim_{x \downarrow 0} E[Y_i | x_i = \xi] - \lim_{x \uparrow 0} E[Y_i | x_i = \xi]$$

where $\hat{\tau}$, represents a "weighted average across cutoffs of the local average treatment effects across all units facing each particular cutoff value" (Bertanha, 2019). Formally, this implies that the average effect of treatment does not vary with higher values of R-GPCD. I identify $\hat{\tau}$ by estimating the following reduced-form equation:

$$Y_i = D_i \hat{\tau} + \delta_1 f(x_i) + \delta_2 f(x_i) * D_i + \beta_1 N_i + \beta_2 E_i + \beta_3 N_i * E_i + \beta_4 X_i + \epsilon_i, \quad (1)$$

where D_i denotes treatment status. $N_i \in \{low, high\}$ denotes the level of "nosy" preferences in the months prior to the mandate, and $E_i \in \{low, high\}$ denotes level of enforcement. The function $f(x_i)$ is a polynomial of the distance from the cutoff, x_i. In the main specification, $f(x_i)$ is a simple linear function.

Following Calonico et al. (2019), I include additional covariates, represented by X_i, to account for differences among utilities with similar GPCDs using a simple covariate-adjusted estimator. This estimate is consistent under the assumption that the treatment has no mean effect on the covariates at the cutoffs. I control for water utility-specific characteristics, including the percentage of residential water usage that is usually delivered to single family households, an indicator variable for whether or not the water utility is regulated by public utility commission, and an indicator variable for whether or not groundwater is the primary source of water. I also control for the severity of local drought conditions that each water utility experienced during the mandated conservation period, measured as the number of months in extreme drought conditions (Palmer Drought Severity Index measure of -4 or less).

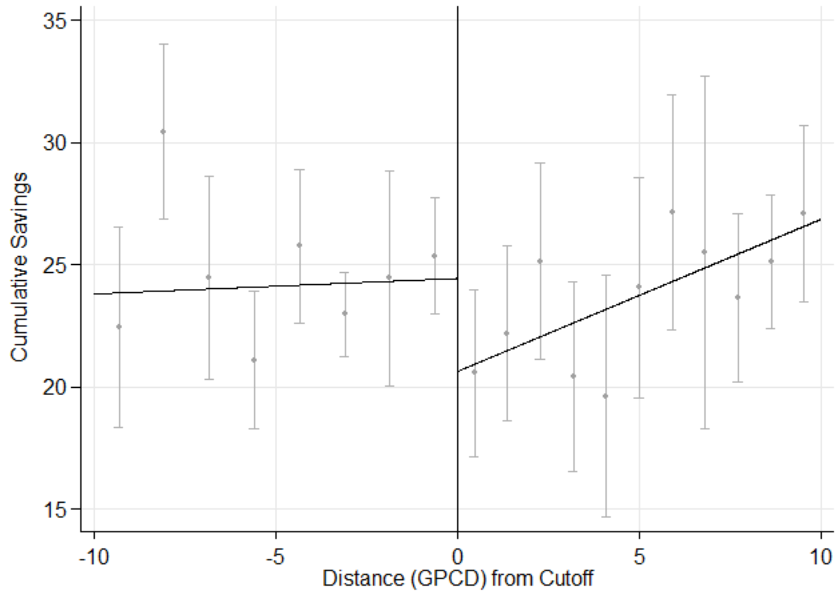
During the drought, public awareness campaigns ranged from ads on radio and/or TV, sending out flyers, hanging up banners, or sending staff to engage with private citizens at farmer's markets. Because these public awareness campaigns are likely to have had spillover effects, I identify each water utility's primary Nielsen district market areas (DMAs) to capture the general effect of public awareness of campaigns. Each of these areas represents regions in which households can be expected to have received the same (or similar) media content (e.g., television, radio, newspaper, internet). In the main specification, I account for media-related spillover effects that would have affected awareness levels in other service areas within the same DMA by clustering standard errors at the DMA level.[16] In Appendix Table C1 and Appendix Table C2, I consider alternative approaches to accounting for media-related spillover effects. In particular, I estimate a model where standard errors are clustered at the water utility level and another model where DMA fixed effects are included as controls. The results from these alternative approaches are qualitatively similar to the main set of results.

I estimate (1) using the percentage cumulative water production savings achieved by utilities during the mandatory conservation period relative to their 2013 production levels as the outcome of interest, Y_i. I provide estimates of (1) for key coefficients in Table 2. I provide results for several different distance bandwidths to serve as a sensitivity check; narrowing the bandwidth ensures increased similarly in terms of R-GPCD at the expense of fewer observations.

Starting with the estimated coefficients for the effect of receiving a higher conservation target, the results show that the differential incentives provided by the mandate did not have a

[16]In California, there are 13 DMAs with an average of 27 water utilities per DMA. I obtain spatial boundary information for DMAs from Gaurav (2016).

Figure 5: Regression Discontinuity Results for Water Conservation



Notes: The central line is a linear fit, fitted separately on each side of the pooled threshold. None of the water utility are included in more than one interval.

strong effect. Though generally statistically insignificant at smaller bandwidths, point estimates for the effect of treatment is negative. This finding would indicate that water utilities with higher conservation targets generally did not conserve more than similar water utilities with lower targets, and may have conserved less water than otherwise similar water utilities. This may indicate a "giving up" effect if water utilities were far enough from their assigned target. A complementary explanation is that fines for municipalities that failed to achieve mandated reductions may not have been that important. This result would suggest that mandating specific targets do not seem to resolve the principal-agent problem between the state and water utilities. Figure 5 graphically depicts the discontinuity in water conservation induced by the SWRCB's policy.

Table 2: Results for Cumulative Production Savings

	Bandwidth (R-GPCD)				Optimal
	4	5	6	7	Bandwidth
Higher conservation target	-1.757	-0.911	-3.604**	-3.109**	-2.441
	(0.970)	(1.549)	(1.384)	(1.019)	(1.738)
Distance	0.488	-0.124	0.140	-0.0693	0.0316
	(0.532)	(0.400)	(0.302)	(0.211)	(0.525)
Higher conservation target*distance	-0.606	-0.568*	0.548	0.582*	0.0934
	(0.517)	(0.260)	(0.377)	(0.270)	(0.369)
High complaints, low effort	5.684*	5.813**	5.402**	4.652**	5.678**
	(2.622)	(1.913)	(1.809)	(1.834)	(1.969)
Low complaints, high effort	0.525	0.937	1.326	0.458	1.585**
	(0.759)	(0.522)	(0.787)	(0.795)	(0.613)
High complaints, high effort	4.634***	4.962***	4.809***	4.702***	5.331***
	(1.261)	(1.010)	(0.931)	(0.884)	(0.926)
Months in severe drought	-0.365*	-0.410***	-0.405***	-0.432***	-0.445***
	(0.166)	(0.0887)	(0.0963)	(0.0904)	(0.0970)
Regulated by CPUC	4.967***	4.067***	2.861**	2.864**	3.095**
	(1.370)	(1.227)	(1.275)	(1.237)	(1.100)
Regional urban management plan	1.550	1.860	1.122	1.049	1.610
	(1.509)	(1.262)	(1.344)	(1.417)	(1.115)
Primarily supplied by groundwater	-2.324	-3.042**	-1.981*	-1.852*	-2.821**
	(1.550)	(1.116)	(1.040)	(0.939)	(1.068)
Percent residential single family	0.0534	0.0614*	0.0564	0.0845**	0.0655*
	(0.0435)	(0.0323)	(0.0314)	(0.0281)	(0.0319)
Constant	21.28***	20.16***	20.91***	18.76***	20.20***
	(4.309)	(2.804)	(2.621)	(2.554)	(2.557)
Observations	121	155	182	205	173
R^2	0.295	0.310	0.247	0.262	0.276

Notes: Standard errors clustered at the DMA level are in parentheses. *** p<0.01, ** p<0.05, * p<0.1

I also explore the effect of treatment at each of the specified cutoffs.[17] Given that the assignment of conservation targets (treatment) is based on a deterministic function of water utilities' summer 2014 R-GPCD, I follow Cattaneo et al. (2016) in estimating a regression discontinuity with cumulative cutoffs. Using this framework, identification of average effects at each cutoff $c_j \in C_k$ is given by:

$$\hat{\tau}_j = \lim_{x \downarrow c_j} E[Y_i | x_i = \xi] - \lim_{x \uparrow c_j} E[Y_i | x_i = \xi]$$

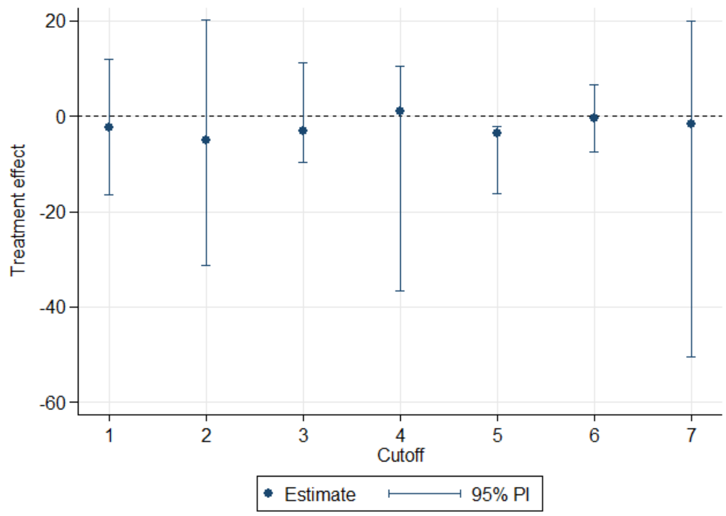
Bandwidths are chosen to restrict observations around each cutoff such that no observation is below or above the preceding or following cutoff, respectively. For example, the maximum range around the second cutoff, 80, is restricted to R-GPCD values between 65 and 94. Not doing so would result in inconsistent estimators (Cattaneo et al., 2016).

As shown in Figure 6, the point estimates for the effect of receiving a higher conservation target at the various cutoffs is negative though generally not statistically different from zero. The estimate at the fifth cutoff (comparing utilities with a 24% target with those receiving a 28% at the 130 GPCD cutoff) is negative and statistically significant. The results of this estimation are robust to the choice of bandwidth, choice of kernel, and inclusion of various sets of covariates and support the pooled estimation results in Table 2.

Turning to the effects of water utility effort and social opprobrium in enforcement, the results suggest that the effect of social opprobrium was significant. All else equal, water utilities serving customers with "nosy" preferences conserved more than otherwise similar water utilities. Using the results estimated with the most narrow bandwidth, water utilities with high complaints and high effort conserved 2.4 percentage points more than water utilities with low effort and low complaints. Similarly, water utilities with high complaints and low effort conserved 2.8 percentage points more than water utilities with low effort and low complaints. The results indicate that conservation levels among water utilities with high effort and low complaints were not statistically different from those with low effort and low complaints. These findings suggest that "nosy" preferences affect the levels of water conservation that water utilities are able to achieve. Given that (1) does not explicitly include the effect of DSM strategies, one potential concern is that water waste complaints may be a proxy for measures implemented by the water utility and not necessarily reflect the role of social

[17] This model is estimated using using the "rdmulti" routine in Stata (Cattaneo, Titiunik and Vazquez-Bare, 2020).

Figure 6: Cutoff-Specific Regression Discontinuity Estimates



opprobrium. In Appendix B, I make use of information related to DSM strategies included in water utilities' management plans and find that that this is likely not the case. In Appendix C, I estimate several additional models to probe the sensitivity of these results to alternative specifications. Notably, in Appendix Table C3 I estimate the effect of social opprobrium for all water utilities in the dataset under various specifications without the use of a RD. The results from these auxiliary models support the main finding that water utilities with "nosy" preferences conserved more than other water utilities.

5 Discussion and Conclusion

The use of higher-level governments use of mandates to impose safeguards and mitigate the consequences of droughts can be expected to continue. It is therefore important to draw lessons from California's experience to inform future policy. In this paper, I use data for California water utilities subjected to a year-long emergency water conservation government mandate. I exploit the mandate's multi-tier approach assigning conservation targets to estimate the extent to which water utilities conserved water due to the assigned targets.

The results suggest that mandating higher targets alone does not necessarily solve the principal-agent problem that state regulators often face. Indeed, I find that, on average, water utilities that were assigned higher conservation targets did not conserve significantly more than otherwise similar water utilities that were assigned a lower conservation target. There are several possible reasons for this finding. One possible explanation is that the RD design is underpowered at narrower bandwidths making it difficult to detect small increases in conservation by water utilities with higher conservation targets. In this case, it is likely that the conservation targets at each of the cutoffs were not large enough to induce large amounts of conservation. Though beyond the scope of this paper, this suggests that a better understanding of the process through which the cutoff values are set is needed. Another explanation is that it was difficult for the SWRCB to enforce its "contract" with water utilities. Though the SWRCB could observe and contract upon outcomes, the importance of fines for municipalities that failed to achieve mandated reductions is unclear. To my knowledge, the SWRCB only pursued legal action against four of the water utilities for failing to comply with their mandated conservation target.[18] A third more likely explanation is that social opprobrium facilitated conservation. Throughout the drought, private citizens were encouraged to anonymously identify and complain about other users that used water in ways deemed "wasteful." In support of this explanation, I find that water utilities servicing areas with more customer-driven complaints regarding "water waste" were able to conserve more. This finding is consistent with previous work that finds that extracting agents operating in complex social networks can be pressured into complying, depending on the population of compliers and the nature of the network (Marco and Goetz, 2017). Additionally, I find that water utilities exerting high effort but with low reported instances of "water waste" were not statistically different from water utilities exerting low effort and low reported instances of "water waste," suggesting that aggressive actions in the absence of public support may not yield desired objectives. This finding is consistent with previous findings that enforcement actions do not have long terms effects on individual use (Zhang and Teodoro, 2018; Browne, Gazze and Greenstone, 2019) and emphasizes the importance of customer buy-in.

At a local level, the findings in this paper highlight the importance of the role of local-level interactions that drive social opprobrium. From a policy perspective, this emphasizes the need for community engagement. Though several utilities indicated that they engaged the community at farmer's markets, banners, radio ads, and other means in the comments section of the data, it is not

[18]See SWRCB (2015*c*) for an example of formal legal action.

possible to study the link between these approaches and social opprobrium using the SWRCB data. Moreover, there are no clear associations between "nosy" preferences and demographic characteristics. A potential avenue for future research would therefore be to study the mechanisms through which "nosy" preferences arise and how water utilities can effectively engage these customers.

At the state level, the implications are three-fold. First, the relevance of private citizen activism highlights the importance of the state portal for reporting instances of water waste. The portal not only enables customers to engage in monitoring behavior but it also can provide valuable information to the state regarding local attitudes towards water conservation. Second, this study underscores the need to improve reporting standards. The data reporting requirements of the SWRCB are laudable in that it improves transparency of information. Yet, there were substantial inconsistencies regarding how water utilities reported data on warnings, penalties, and rate penalties that likely stemmed from confusion over definitions. Lastly, the SWRCB dataset primarily consisted of information on enforcement. Over the course of EO B-29-15, water utilities across the state adopted additional demand management strategies that are not captured in the dataset. In spite of a large (and growing) literature on demand management strategies for managing water demand, there is much uncertainty regarding the relative efficacy of these strategies. Moreover, little is known regarding how social opprobrium can be harnessed as a demand management strategies. Future reporting requirements should also aim to collect information on the various demand management strategies to better understand these dynamics in the context of promoting conservation.

Appendices

Appendix A Service Area Characteristics

In Appendix Table A1, I provide summary statistics on service area characteristics that may be associated with “nosy” preferences, where the level of “nosy” preferences is defined in terms of relative level of per capita water waste complaints in the months prior to the start of the state mandate for water conservation. In particular, I provide summary statistics on four categories of categories of characteristics. First, I provide information on the average amounts of water that water utilities generally provide to various customer classes obtained from their 2015 urban water management plans submitted to CA Department of Water Resources. Second, I provide information regarding density using a variety of metrics. I construct two simple measures of density: the first defined in terms of population per square mile and the second in terms of the number of service connections per square mile. The numerator used for these measures are obtained from US. Environmental Protection Agency’s Safe Drinking Water Information System. The denominator, area, is computed using GIS from spatial maps of each water utility’s service area boundaries. I also provide measures from two additional sources. I provide information on the percentage of people for whom their work commutes exceeds one hour using data at the US Census Block Group level.[19] Lastly, I also compare service areas using a measure of geographic isolation developed by Doogan et al. (2018) at the US Census Tract level. This measure is meant to capture geographical differences based on measures that correlate strongly with population density and access to resources in relative close proximity. Third, I compare measures social and demographic characteristics at the US Census Block Group level. These characteristics include race, education, and per-capita income. Lastly, I also provide information on housing characteristics also at the US Census Block Group level. Water utilities do not seem to significantly differ along any of the characteristics examined.

[19]Census data is obtained from US Census obtained from IPUMS National Historic Geographic Informaion System (NHGIS) based on 2015 American Community Survey 5 year (2011-2015) estimates (Manson et al., 2017).

Appendix Table A1: Service Area Characteristics by Level of "Nosy" Preferences

	All Service Areas		***Service Areas by "Nosy" Preferences***			
			Low		***High***	
Water Usage Characteristics						
% Residential usage	69.95	(13.35)	70.25	(13.76)	69.64	(12.96)
% Distibution system losses	7.19	(6.19)	7.86	(6.58)	6.53	(5.72)
% Landscaping	5.46	(5.95)	5.08	(5.93)	5.83	(5.96)
% Industrial	2.92	(7.42)	2.89	(6.37)	2.96	(8.34)
% Agriculatural/Irrigation	1.87	(8.58)	1.38	(6.16)	2.36	(10.42)
% Commercial	12.06	(9.65)	12.88	(10.48)	11.26	(8.71)
Measures of Density						
Pop./Sq. Mile	4208.45	(8163.99)	4262.36	(3732.06)	4154.85	(10929.18)
Service connections/Sq. Mile	1024.27	(1437.97)	991.99	(719.17)	1056.36	(1902.41)
% Pop. work commute 1hr+	10.90	(5.65)	11.99	(5.95)	9.80	(5.13)
Isolation Distance	4.55	(1.17)	4.48	(1.22)	4.62	(1.13)
Isolation Time	4.57	(1.18)	4.50	(1.22)	4.64	(1.14)
Demographic Characteristics						
% Caucasian	68.09	(15.53)	64.80	(15.76)	71.38	(14.61)
% African American	4.29	(4.91)	5.07	(5.92)	3.51	(3.47)
% Asian	10.81	(11.61)	11.38	(12.57)	10.25	(10.57)
% College degree or higher	10.61	(7.74)	9.63	(7.67)	11.59	(7.71)
Per capita income (1000 USD)	31.27	(13.62)	29.89	(13.85)	32.65	(13.27)
Housing Characteristics						
Average household size	3.05	(0.45)	3.15	(0.46)	2.95	(0.41)
% Vacant housing units	8.86	(9.20)	8.53	(8.62)	9.20	(9.76)
% Rental units utilities included	6.67	(3.44)	6.78	(3.32)	6.57	(3.56)
Median rent	1253.93	(308.59)	1288.68	(298.82)	1219.18	(315.01)
Median housing value (1000 USD)	421.61	(220.78)	437.98	(229.20)	405.25	(211.35)
Number of housing units	644.11	(159.48)	634.94	(171.62)	653.28	(146.21)

Notes: "Nosy" preferences are defined in terms of relative level of per capita water waste complaints in the months prior to the start of the state mandate for water conservation. US Census estimates are based on 2015 American Community Survey 5 year estimates (2011-2015).

Appendix B Demand Side Management Strategies

The main specification in this paper does not explicitly include the effect of DSM strategies on conservation because of data limitations on the use of the strategies themselves and the timing of their implementation. Given that a water utility may simultaneously implement several DSM strategies, it is possible that water utilities that are enthusiastic about implementing DSMs may have also been enthusiastic about encouraging their customers to report instances of water waste. In this case, water waste complaints may be a proxy for implemented measures and not necessarily reflect the role of social opprobrium.

Previous studies fcous on the effects of price-based strategies in promoting conservation. In particular, there are a growing number of studies that shows that prices can be an effective means to achieve reductions in water usage (Nataraj and Hanemann, 2011; Mansur and Olmstead, 2012; Baerenklau, Schwabe and Dinar, 2014; Klaiber et al., 2014; Wichman, Taylor and Von Haefen, 2016; Browne, Gazze and Greenstone, 2019; El-Khattabi et al., 2020). In fact, Browne, Gazze and Greenstone (2019) find that prices played an important role in reducing water usage in Fresno, CA during the 2015-16 mandated conservation period. In spite of this growing body of work, however, water utility managers prefer using price increases primarily as a means for cost recovery rather than to promote conservation (Maggioni, 2015; Buck et al., 2016). Notably, many price elasticity estimates have been found to be low (Pint, 1999).[20] Because low elasticities imply that prices would have to be increased by a significant amount to achieve desired reductions, water utility managers are generally sensitive to concerns over equity and the political feasibility of raising prices (Hall, 2009; Teodoro, Zhang and Switzer, 2018), in addition to "demand hardening" as customers exhaust means of reducing water usage (Howe and Goemans, 2007).

To address the concern that water waste complaints may be a proxy for implemented measures, I make use of the DSM strategies included in the water management plans that water utilities reported to the DWR in 2015. The strategies listed in the plans have two main shortcomings. First, water utilities are not bound by the strategies they include in their plans. In other words, water

[20]The majority of studies that find low price elasticities are usually calculated using relatively small price variations or studies that examine the use of increasing block tariffs (IBT), one of the most popular pricing schemes. There is a large literature that questions the issue of price salience and whether customers are able to properly interpret price signals under IBT (Howe and Linaweaver, 1967; Shin, 1985; Nieswiadomy and Molina, 1991; Cavanagh, Hanemann and Stavins, 2002; Ito, 2014; Wichman, 2014).

utilities may not implement the strategies included or, equivalently, implement strategies not listed in their plans. Second, the information provided does not reflect the implementation intensity with which they may have been implemented. The listed strategies are nonetheless useful in this context because planning documents are a result of the water utility's own planning initiative. This information can therefore be useful in attempting to understand the relationship between water waste complaints and attitudes at the water utility level. Using this information, I estimate two additional models. First, I estimate a model to investigate the relationship between the number complaints per capita received prior to the beginning of the mandate and the DSMs stated in the plans given by (2):

$$C_i = \alpha + \beta M_i + \epsilon_i, \tag{2}$$

where the dependent variable, C_i, represents the number of complaints per capita received in the months before the mandate and M_i is a vector of the various DSM strategies listed in each of the water utilities management plan. I also estimate a model to investigate the relative effect that complaints and DSMs have on cumulative savings, given by (3):

$$Y_i = \alpha + \beta C_i + \gamma M_i + \epsilon_i, \tag{3}$$

where the dependent variable, Y_i, represents cumulative water savings during the mandated conservation period.

The results from (2), shown in the first column of Appendix Table B1, indicate that water waste complaints are not a proxy for actions that water utilities took to encourage conservation and uncorrelated with public information campaigns. More importantly, complaints do not seem to be associated traditional DSM strategies, such as price-increases or drought pricing or drought surcharges. Complaints are higher in areas where the water utility had proposed organizing water waste patrols. The results from (3), shown in the second column of Appendix Table B1, suggest that increasing the frequency of meter reading and the number of complaints prior to the mandate are both positively and statistically associated with cumulative savings. Of note, cumulative savings seems to be negatively associated with rebates for turf replacement.

Appendix Table B1: Nosy Preferences in the context of Demand Side Management Strategies

VARIABLES	(1) Complaints per capita	(2) Cumulative Savings
Complaints per capita (prior to mandate)		5.528***
		(1.355)
Expand Public Information Campaign	-0.0836*	1.330
	(0.0505)	(1.024)
Implement/Modify Drought Rate Structure/Surcharge	0.0423	0.810
	(0.0397)	(0.866)
Increase Frequency of Meter Reading	0.0673	1.701*
	(0.0562)	(0.944)
Increase Water Waste Patrols	0.0882**	0.468
	(0.0400)	(0.885)
Moratorium on New Connections	0.0576	0.694
	(0.0388)	(0.790)
Offer Water Use Surveys	-0.0478	0.940
	(0.0372)	(0.785)
Provide Rebates for Landscape Irrigation Efficiency	0.0197	0.672
	(0.0311)	(0.891)
Provide Rebates for Turf Replacement	-0.0235	-1.962**
	(0.0360)	(0.844)
Provide Rebates on Plumbing Fixtures and Devices	0.0180	0.104
	(0.0339)	(0.982)
Reduce System Water Loss	-0.0783**	-0.417
	(0.0305)	(0.812)
Other	0.0180	-0.303
	(0.0284)	(0.707)
Constant	0.200***	22.51***
	(0.0464)	(0.978)
Observations	378	378
R^2	0.052	0.106

Notes: Robust standard errors are in parentheses. *** $p<0.01$, ** $p<0.05$, * $p<0.1$

Appendix C Sensitivity Analysis

In the main paper, I account for media-related spillover effects that may have affected awareness of drought by clustering standard errors at the DMA level. In this section, I consider alternative approaches to account for this effect.

A potential concern is that the clustering standard errors at the DMA level may result in higher standard errors due to the relatively small number of DMAs. To alleviate this concern, I instead cluster standard errors at the water utility level. The significance of the results from estimating this specification, shown in Appendix Table C1, are unchanged relative to the main results.

In Appendix Table C2, I control directly for DMA fixed effects in the model to control for any unobserved spatial heterogeneity. In doing so, it should be noted that treatment effects are identified between water utilities on either side of the RD cutoff within the same DMA. The results are qualitatively similar to the main results.

In Appendix Table C3, I estimate the effect of social opprobrium for all water utilities in the dataset. In column A, standard errors are clustered at the DMA level. In column B, standard errors are clustered at the water utility level. In column C, DMA fixed effects are included in the model. The results from these alternative specifications support the main finding that water utilities with high levels of complaints conserved more than water utilities with low levels of complaints.

Appendix Table C1: Clustering Standard Error at Water Utility Level

	Bandwidth (R-GPCD)				Optimal
	4	5	6	7	Bandwidth
Higher conservation target	-1.757	-0.911	-3.604**	-3.109*	-2.441
	(2.042)	(1.638)	(1.662)	(1.599)	(1.673)
Distance	0.488	-0.124	0.140	-0.0693	0.0316
	(0.603)	(0.419)	(0.357)	(0.314)	(0.412)
Higher conservation target*distance	-0.606	-0.568	0.548	0.582*	0.0934
	(0.763)	(0.401)	(0.401)	(0.318)	(0.391)
High complaints, low effort	5.684***	5.813***	5.402***	4.652***	5.678***
	(2.154)	(1.669)	(1.596)	(1.456)	(1.625)
Low complaints, high effort	0.525	0.937	1.326	0.458	1.585
	(1.462)	(1.243)	(1.146)	(1.146)	(1.145)
High complaints, high effort	4.634***	4.962***	4.809***	4.702***	5.331***
	(1.356)	(1.161)	(1.143)	(1.137)	(1.152)
Months in severe drought	-0.365***	-0.410***	-0.405***	-0.432***	-0.445***
	(0.134)	(0.114)	(0.112)	(0.108)	(0.114)
Regulated by CPUC	4.967***	4.067***	2.861*	2.864**	3.095**
	(1.731)	(1.421)	(1.467)	(1.364)	(1.456)
Regional urban management plan	1.550	1.860	1.122	1.049	1.610
	(1.376)	(1.159)	(1.042)	(1.119)	(1.095)
Primarily supplied by groundwater	-2.324*	-3.042***	-1.981*	-1.852*	-2.821**
	(1.349)	(1.136)	(1.099)	(1.048)	(1.109)
Percent residential single family	0.0534	0.0614	0.0564	0.0845**	0.0655*
	(0.0506)	(0.0419)	(0.0361)	(0.0347)	(0.0374)
Constant	21.28***	20.16***	20.91***	18.76***	20.20***
	(4.874)	(3.825)	(3.464)	(3.385)	(3.583)
Observations	121	155	182	205	173
R^2	0.295	0.310	0.247	0.262	0.276

Notes: Standard errors clustered at water utility level are in parentheses. *** p<0.01, ** p<0.05, * p<0.1

Appendix Table C2: Inclusion of District Market Area (DMA) Fixed Effects

	Bandwidth (R-GPCD)				Optimal
	4	5	6	7	Bandwidth
Higher conservation target	-0.930	-0.250	-2.883*	-2.340	-1.380
	(1.759)	(1.458)	(1.560)	(1.478)	(1.546)
Distance	0.554	-0.129	0.330	0.111	0.0415
	(0.529)	(0.371)	(0.328)	(0.298)	(0.358)
Higher conservation target*distance	-0.813	-0.590*	0.307	0.290	-0.124
	(0.637)	(0.348)	(0.390)	(0.291)	(0.374)
High complaints, low effort	3.606*	3.468**	3.373**	2.571*	3.521**
	(1.924)	(1.621)	(1.627)	(1.407)	(1.575)
Low complaints, high effort	-0.153	0.257	0.395	-0.465	0.604
	(1.264)	(1.122)	(1.087)	(1.061)	(1.046)
High complaints, high effort	3.074**	3.184***	3.066**	2.992**	3.686***
	(1.325)	(1.184)	(1.246)	(1.184)	(1.210)
Months in severe drought	0.106	0.0509	0.119	0.157	0.111
	(0.225)	(0.165)	(0.158)	(0.151)	(0.161)
Regulated by CPUC	3.853*	2.766*	1.599	1.644	1.997
	(2.106)	(1.612)	(1.578)	(1.465)	(1.585)
Regional urban management plan	2.810*	3.302**	1.963	1.865	2.918**
	(1.564)	(1.341)	(1.440)	(1.498)	(1.361)
Primarily supplied by groundwater	-1.663	-1.955*	-0.421	-0.0738	-1.290
	(1.211)	(1.075)	(1.114)	(1.053)	(1.058)
Percent residential single family	0.0684	0.0707*	0.0708**	0.0974***	0.0813**
	(0.0455)	(0.0371)	(0.0335)	(0.0329)	(0.0341)
Constant	16.94***	16.33***	16.57***	14.09***	14.98***
	(4.656)	(3.524)	(3.373)	(3.360)	(3.388)
Observations	121	155	182	205	173
R^2	0.496	0.512	0.440	0.447	0.479

Notes: Models also include DMA fixed effects. Robust standard errors are in parentheses. *** p<0.01, ** p<0.05, * p<0.1

Appendix Table C3: Effect of Social Opprobrium without the use of RD

	A	B	C
High complaints, low effort	4.597***	4.597***	3.256***
	(0.717)	(0.964)	(0.948)
Low complaints, high effort	0.970	0.970	0.700
	(0.629)	(0.927)	(0.877)
High complaints, high effort	5.740***	5.740***	4.893***
	(0.778)	(0.996)	(1.043)
Months in severe drought	-0.406***	-0.406***	-0.0915
	(0.0733)	(0.0715)	(0.112)
Regulated by CPUC	2.960***	2.960***	2.417**
	(0.823)	(1.006)	(1.032)
Regional urban management plan	1.179*	1.179	2.231
	(0.622)	(1.417)	(1.553)
Primarily supplied by groundwater	-1.536**	-1.536**	-0.568
	(0.616)	(0.766)	(0.743)
Percent residential single family	0.116***	0.116***	0.131***
	(0.0169)	(0.0277)	(0.0281)
Constant	16.12***	16.12***	12.81***
	(1.424)	(2.414)	(2.537)
Observations	386	386	386
R^2	0.268	0.268	0.387
Cluster SE	DMA	PWSID	NO
DMA FE	NO	NO	YES

Notes: Standard errors are in parentheses. *** p<0.01, ** p<0.05, * p<0.1

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