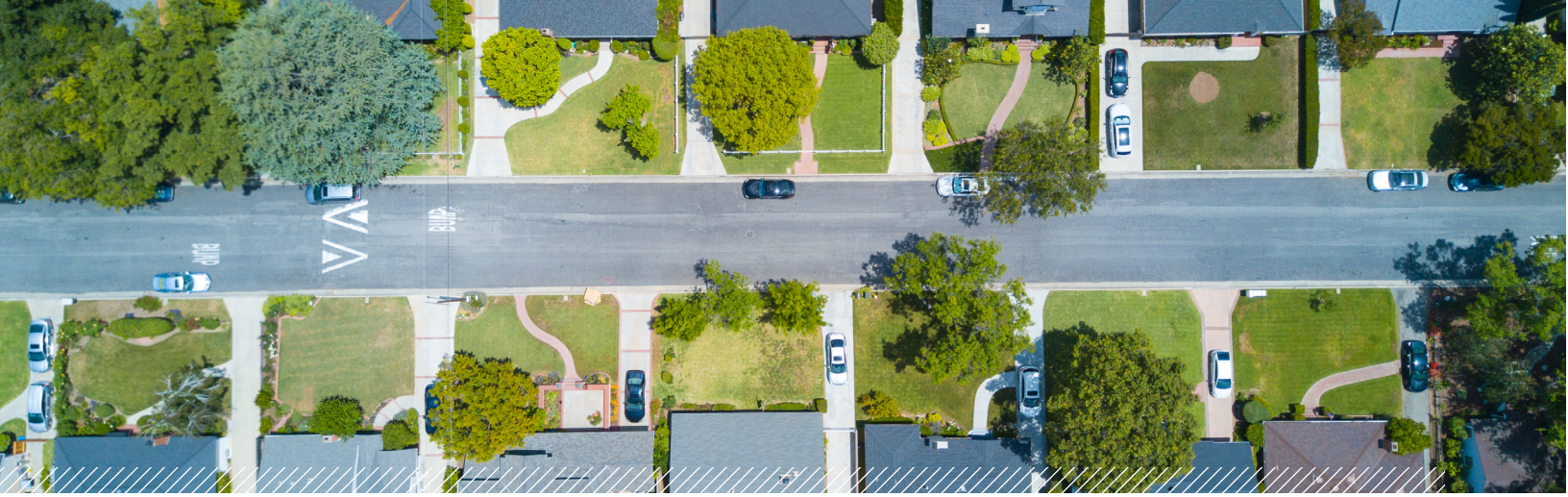


RESEARCH SUMMARY

Man vs. Machine: Technological Promise and Political Limits of Automated Regulation Enforcement

by Oliver R. Browne, Ludovica Gazze, Michael Greenstone, Olga Rostapshova

KEY TAKEAWAYS

1. Technological advances in remote sensing and real-time monitoring have the potential to dramatically lower the costs and improve the accuracy of environmental enforcement, but political considerations limit take-up.

2. The Energy & Environment Lab at the University of Chicago partnered with a city in California to evaluate the use of smart meters to target and enforce water restrictions. The project was the first to experimentally study the environmental benefits and political costs of automated monitoring of water use in a real-world enforcement setting.

3. The new system worked dramatically better than the status quo approach of "water cops" driving around looking for illegal water consumption (e.g., watering lawns on prohibited days). The improved detection and enforcement decreased violations by 17 percent and decreased the number of households in violation by 8 percent per month.

4. Automated enforcement decreased summer water consumption by 3 percent, and households continued to conserve even after the summer months.

5. These benefits came with substantial costs to city officials as customer service calls to the city-owned utility identified as complaints and disputes of enforcement actions increased by 1,102 percent. In response to the political backlash to the use of the smart meter data to enforce restrictions, the city decided to terminate the program. as the number of households

6. The adoption of remote sensing and continuous monitoring technologies to improve environmental enforcement has game-changing potential. But as policymakers adapt aging regulations to incorporate these sources of real-time data, the clear environmental benefits will need to be balanced against possible political costs, e.g., by designing programs that calibrate community expectations.

Introduction

Ensuring compliance with environmental regulations has historically been difficult because 1) detection of violations is costly (i.e., typically in the form of in-person inspections), and 2) individuals and firms may take actions to hide their violations. However, advances in remote sensing and real-time monitoring technology are rapidly and radically lowering the costs of detecting violations to almost zero. As California's cities work to develop strategies to cope with drought conditions at least partially due to climate change, smart meters could be a valuable tool to help regulate water use, in particular outdoor use, which is the single largest end-use of residential water.

The researchers worked with one of California's largest cities, which was one of the first to adopt universal smart meters for single-family residential customers. But despite collecting real-time data on water use for every household, the city was not using this rich and granular data to detect violations or issue fines, or to enforce outdoor watering restrictions. Instead, the city, like almost all other cities, employed "water cops" to drive around to detect lawns being watered at prohibited times.

This paper studies the use of smart meter data to identify and enforce residential outdoor water use regulations designed to help cities cope with water scarcity. It is the first to experimentally study the conservation benefits and the political costs of continuous and inexpensive remote monitoring in a real-world enforcement setting.

Research Design

The researchers worked with a city in California to design and implement a field experiment that used data from smart meters to detect violations across the nearly 100,000 households in the city. The experiment was conducted between July and September 2018, during peak outdoor watering season, and aimed to inform the city-wide implementation of automated enforcement and a new fine schedule.

During the experiment, each single-family household in the city was assigned to one of twelve groups, across which regulations were designed to vary along several cross-randomized dimensions: 1) enforcement methods: whether households were newly subject to automated enforcement via smart meters or continued the status quo of visual inspection by water cops, and 2) the magnitude of fines levied for violations—either a normal fine schedule, or one of two reduced fine schedules: either half or a quarter of the norm.

Within the automated enforcement group, the researchers further randomized households into one of three `excessive water use' thresholds that defined a violation: either 300, 500, or 700 gallons per hour.

To evaluate the impact of the program, the researchers assessed outcomes including: how well households complied with the regulations, how the regulations impacted water use, and the frequency of customer service calls (e.g., complaints). The latter measure allowed the researchers to assess the political ramifications of increased enforcement.

Findings

The automated enforcement of water conservation rules using smart meters caused a 17 percent reduction in violations.
Historical smart meter data showed that violations of outdoor water restrictions were rampant, but the city was not using these data for issuing fines. For example, in 2016, 68 percent of the city's roughly 100,000 households had consumed more than 300 gallons per hour on a day when outdoor watering was illegal at least once. Yet, it was not possible for the part-time water cops to directly observe all of these violations and so they only issued about 3,100 fines to just 0.4 percent of households.

In 2017, the typical household used more than 300 gallons of water per hour during a time when outdoor watering was prohibited approximately once a week. This means that the city would have detected about 12,000 violations per day if the smart meter data were being used for monitoring and enforcement.

In 2018, the introduction of automated enforcement using smart meter data worked dramatically better than the "water cops" approach in detecting violations. As a result, the share of households fined for non-compliance increased from 0.1 percent under the previous system to 14 percent under the automated enforcement. The increased probability of detection caused more households to comply with the water conservation rules—there was a 17 percent reduction in violations. Additionally, 8 percent fewer households were in violation in a typical month during the experiment.

In total, using smart meter data to pinpoint violators and enforce the water restrictions greatly increased the water fines paid by households. On average, households subject to automated enforcement paid $7.43 more per month in fines than those monitored by the water cops over the duration of the study. If these results were scaled city-wide, more than 16 percent of households would be fined per summer month and the city would collect $2.55 million in fines over the course of the summer.

Automated enforcement decreased water consumption by about 3 percent over the summer. If it were scaled citywide, it would lead to water savings of 174 million gallons per summer.
In July, when violations only led to warnings, water consumption decreased by 1.5 percent. By September, once fines had been issued, water consumption decreased by about 3 percent. The decline in water use was driven in part by a decrease in heavy consumption hours: automated enforcement reduced the number of hours during which households had excessive water use more than 500 gallons/hour by 19 percent, and more than 700 gallons/hour by 25 percent. The higher the `excessive water use' threshold households were assigned to, the less likely they were to conserve water.

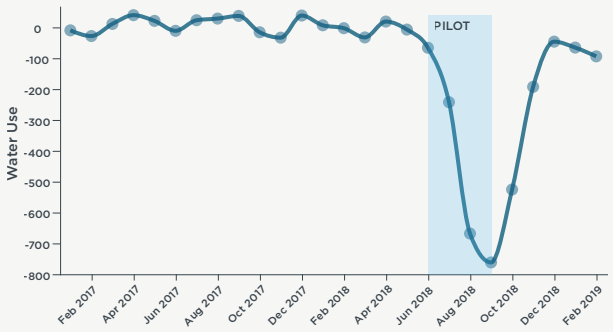
Water consumption of violating households appears to decrease after they receive a warning or fine. This pattern suggests that over the course of the summer households learned to adapt to the new enforcement rules. Interestingly, the study finds that fine magnitude did not affect water consumption. There is also little evidence that households offset the reduction in water use during banned hours by increasing their water use during permitted hours. In addition, household income didn't play a role in what fraction of baseline water use was conserved.

The water savings that accrued over the summer indicate that scaling up the policy city-wide would save 174 million gallons of water

each summer. Such water savings would achieve a fifth of the reductions in residential water use that Governor Gavin Newsom requested of California residents on July 8, 2021, when the state faced another drought.

Further, households subject to automated enforcement continued to use less water even after the pilot program ended. If the water savings in the months after the experiment ended are assumed to persist at the same levels, then scaling automated enforcement city-wide would save 394 million gallons of water annually. In other words, the potential water savings from the permanent adoption of automated enforcement are even larger than the savings during the experiment.

Figure 3 · Effect of Automated Enforcement on Monthly Water Use

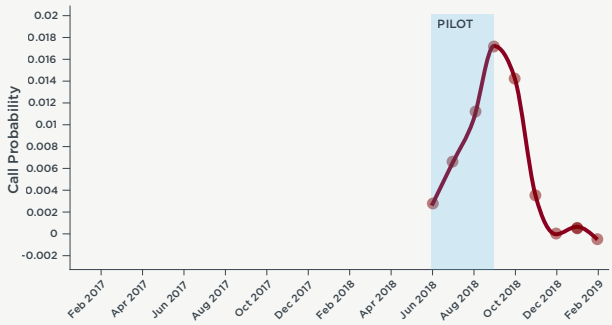


Note: This figure plots the regression-adjusted difference between households in the automated and non-automated group.

Automated enforcement caused a backlash from the community, triggering a 1,102 percent increase in calls of complaints and disputes of enforcement actions.
Households that were fined based on their smart water data were about 50 percent more likely to call customer service—mostly to complain—than households fined by water cops. The heavy water users and the wealthy complained to the customer service department more frequently. Lower fines did not make households less likely to call the water department with complaints.

In total, automated enforcement generated 1,747 additional calls from households to customer service during the three-month experiment—a 654 percent increase—and calls identified as complaints and disputes of enforcement actions increased by 1,102 percent. The political costs of these calls were substantial, at least partially because many were paired with calls to City Council members complaining about the new system. If the city were to scale up automated enforcement citywide, the researchers estimate that it would lead to 4,090 additional calls over the summer period.

Figure 4 · Effect of Automated Enforcement on the Probability of Calling Customer Service



Note: This figure plots the regression-adjusted difference between households in the automated and non-automated group.

Policy Implications

Utilities typically do not price water to reflect incremental social cost, for a variety of political, regulatory, and ethical reasons and instead rely on non-price mechanisms to manage consumption. The study's finding that automated enforcement can produce meaningful reductions in water use demonstrates that this second-best approach can be effective at achieving conservation goals. At the same time, the use of these types of technologies is constrained by the associated political costs. Looking ahead, It is apparent that research on ways to minimize political backlash against improved monitoring could unlock important environmental and social benefits.

The Energy Policy Institute at the University of Chicago (EPIC) is confronting the global energy challenge by working to ensure that energy markets provide access to reliable, affordable energy, while limiting environmental and social damages. We do this using a unique interdisciplinary approach that translates robust, data-driven research into real-world impacts through strategic outreach and training for the next generation of global energy leaders.