Human Right to Water Act and Drinking Water Compliance: A Synthetic Control Approach

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Abstract

This paper evaluates the impact of California's Human Right to Water Act (HR2W) on drinking water compliance using a synthetic control approach. We construct a counterfactual from other U.S. states to estimate the 2016 policy's causal effect. The results show a significant decline in enforcement priority public water systems (PWSs) in California relative to the synthetic counterpart. Robustness checks confirm that this decline is not driven by confounding factors like federal regulations. These findings provide empirical evidence on the effectiveness of targeted water governance policies.

JEL Codes: Q25, Q58, C23

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1 Introduction

Ensuring compliance with drinking water quality standards is a critical policy challenge. Public water systems (PWSs) in the United States operate under federal and state regulations, yet enforcement outcomes vary due to differences in regulatory approaches and implementation capacity (Elbakidze and Beeson 2021; EPA 2025). While compliance is essential to public health and environmental protection, violations persist, raising concerns about the effectiveness of existing regulatory frameworks (Gray and Shimshack 2011). Recognizing the need for stronger enforcement mechanisms, California implemented the Human Right to Water Act (HR2W) in 2016, signaling a policy shift toward enhanced regulatory oversight (California Water Boards 2024). While HR2W established a legal framework prioritizing access to safe drinking water, its effectiveness in improving compliance remains an empirical question.

This study examines the causal impact of HR2W on drinking water compliance, focusing on the extent to which the policy reduced the proportion of enforcement priority PWSs in California. Theoretically, stronger regulatory frameworks can enhance compliance by reducing informational asymmetries, strengthening monitoring mechanisms, and increasing the expected costs of non-compliance (Harrington 1988; Sappington 1991). However, enforcement efforts may also be constrained by institutional capacity, local economic conditions, and resource availability (Earnhart and Glicksman 2015). Whether HR2W successfully mitigated these enforcement gaps and improved compliance outcomes is an open empirical question that this study seeks to address.

To estimate the policy's effect, we employ the synthetic control method (SCM), a data-driven approach that constructs a counterfactual scenario in the absence of HR2W. The SCM framework allows us to compare California's post-treatment compliance trajectory with a weighted combination of states that exhibited similar pre-treatment trends but did not implement comparable drinking water policies. This methodology provides a rigorous causal estimate of HR2W's impact, distinguishing its effect from broader regulatory and economic trends (Abadie et al. 2010).

The results indicate that HR2W led to a significant and sustained decline in enforcement priority PWSs in California relative to the synthetic control. Robustness checks, including placebo tests and alternative control group specifications, confirm that the observed effect is unlikely to be driven by external factors or model specification choices.

This study contributes to the economics of regulation and public policy in several ways. First, it provides empirical evidence on the effectiveness of state-level regulatory interventions in improving compliance outcomes, adding to the literature on environmental and public goods provision. Second, it underscores the importance of causal inference techniques in evaluating policy reforms, showcasing the utility of SCM for assessing regulatory interventions in settings where randomized experiments are infeasible.

The remainder of the paper is structured as follows. Section 2 describes the empirical methodology, detailing the synthetic control approach and data sources. Section 3 presents the main results and robustness checks. Section 4 discusses the broader implications of the findings.

2 Methodology

We employ the SCM to estimate the causal effect of HR2W. SCM is particularly useful in policy evaluations where a single treated unit exists, as it constructs a weighted control group from untreated units to best approximate the pre-treatment trend of the treated unit. The divergence between California and its synthetic control post-2016 provides an estimate of the policy's impact.

2.1 Data

The primary outcome variable is the percentage of PWSs classified as enforcement priority, derived from the EPA's Enforcement and compliance history (EPA 2025) for the years 2014–2023 including treatment period 2016 (T_0). A PWS is designated as enforcement priority when it meets the EPA's criteria for significant non-compliance, including exceeding contaminant limits, failing to meet monitoring and reporting requirements, or exhibiting persistent system deficiencies (EPA 2025). This classification serves as an indicator of regulatory enforcement intensity and compliance performance.

To ensure an appropriate counterfactual, the control group includes only states that

	California	Control Group
log GDP	14.86	12.13
Enforcement Priority (%)		
2014 ($T_0 - 2$)	4.7	4.9
2016 (T_0)	2.5	4.4
2018 ($T_0 + 2$)	0.4	4.1
2020 ($T_0 + 4$)	0.2	4.3

Table 1: Outcome Means – California vs. Control group

did not implement major drinking water policies between 2014 and 2023[1]. This restriction minimizes the risk of confounding due to independent regulatory interventions. The treatment unit is California, with the intervention year set at 2016, following the enforcement of the HR2W.

To improve the comparability of the synthetic control, we include additional covariates that may influence drinking water enforcement outcomes. Specifically, we incorporate the log of real GDP to capture state-level economic conditions, and the number of regulatory site visits sourced from the EPA's Enforcement and compliance history (EPA 2025; U.S. BEA 2025), reflecting state-level enforcement intensity and monitoring capacity. These variables help control for economic and regulatory differences that could affect compliance trends across states. Summary Statistics are presented in Table 1.

2.2 Synthetic Control Approach

To estimate the causal impact of California's HR2W on drinking water compliance, we employ the SCM. SCM constructs a counterfactual by assigning weights to a set of untreated states such that their weighted average closely approximates California's pre-treatment trend in compliance. This allows for an estimation of what would have occurred in the absence of HR2W by comparing the post-treatment divergence between California and its synthetic counterpart.

[1]Excluded states are denoted in Table A1

The outcome variable, Y_{it}, represents the percentage of percentage of PWSs classified as enforcement priority in state i at time t. Letting $i = 1$ denote California, the synthetic control estimator is given by

$$\hat{\tau}_{1t} = Y_{1t} - \sum_{j \neq 1} w_j Y_{jt}, \quad \forall t \geq T_0 \tag{1}$$

where $T_0 = 2016$ is the treatment year, and w_j represents the weight assigned to each donor state. The weights are restricted to sum to one, ensuring that the synthetic control is a convex combination of untreated states,

$$\sum_{j \neq 1} w_j = 1, \quad w_j \geq 0. \tag{2}$$

The optimal weights are chosen to minimize the pre-treatment discrepancy between California and its synthetic counterpart by solving the following minimization problem:

$$\min_w \sum_{t < T_0} \left(Y_{1t} - \sum_{j \neq 1} w_j Y_{jt} \right)^2 . \tag{3}$$

The control group includes only states that did not implement major drinking water policies between 2014 and 2023, ensuring that observed differences in compliance are not influenced by independent regulatory changes in other states.

3 Results

Figure 1 illustrates the trend in enforcement priority PWSs in California and its synthetic counterpart from 2014 to 2023. Prior to 2016, both California and the synthetic control exhibit similar compliance trends, confirming that the constructed counterfactual accurately reflects pre-policy conditions. However, following the implementation of HR2W in 2016, a noticeable divergence emerges. California experiences a substantial and sustained decline in the percentage of enforcement priority PWSs, while the synthetic control remains relatively stable, exhibiting no systematic decrease. This pattern suggests that HR2W played a crucial role in improving regulatory compliance, as California's enforcement priority PWSs declined

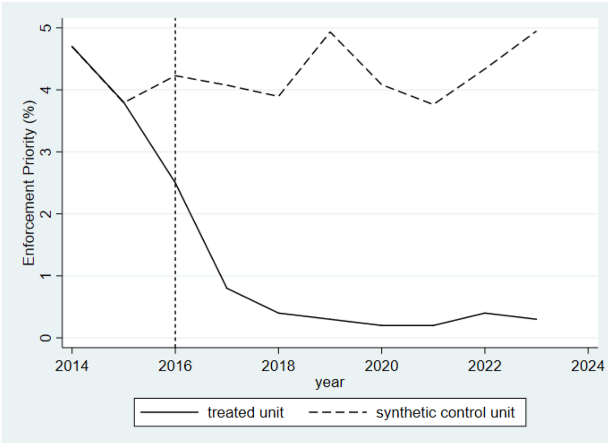

Figure 1: California vs. Synthetic Control

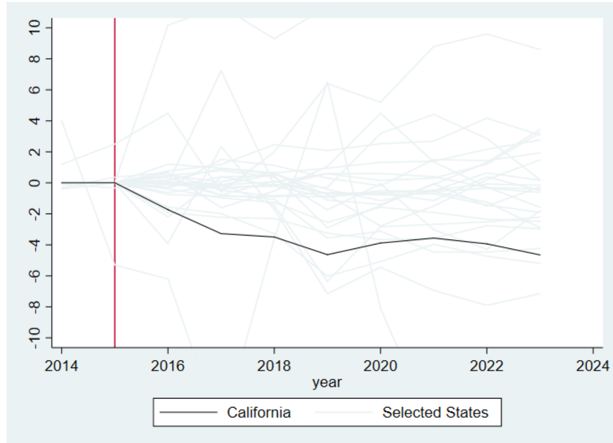

Figure 2: Placebo Experiments

while comparable states without the policy did not experience similar improvements.

To further assess the statistical significance and robustness of this effect, Figure 2 presents placebo tests in which the synthetic control method is applied to other untreated states. The black line represents California, while the light gray lines correspond to placebo-treated states that did not implement HR2W. Prior to 2016, the compliance trends of California and the placebo states are similar, reinforcing the validity of the synthetic control design. After 2016, California exhibits a distinct and persistent decline in enforcement priority PWSs.

Taken together, these findings indicate that HR2W led to a significant reduction in enforcement priority PWSs in California, strengthening compliance with drinking water regulations. The robustness checks confirm that these results are not driven by random fluctuations or selection bias in the donor pool. This provides empirical support for targeted regulatory interventions as an effective mechanism for improving drinking water compliance and public health outcomes.

4 Discussion

The findings of this study provide empirical evidence that the HR2W led to a significant reduction in the percentage of enforcement priority PWSs in California. Using the synthetic control method, we demonstrate that compliance trends in California closely followed those of its synthetic counterpart before 2016, validating the credibility of the constructed counterfactual. However, after the enactment of HR2W, California experienced a sustained decline in enforcement priority PWSs, whereas the synthetic control exhibited no comparable improvement. This divergence strongly suggests that HR2W played a causal role in improving drinking water compliance, highlighting the effectiveness of legislative interventions in addressing regulatory violations in the water sector.

The robustness of these findings is further supported through placebo tests. Placebo tests indicate that while California exhibited a more pronounced and sustained decline in enforcement priority PWSs after HR2W implementation, some states without HR2W also experienced modest improvements. This suggests that broader national or external factors could partially influence observed trends, although California's improvements are notably stronger.

This study contributes to the broader literature on regulatory interventions and environmental governance by providing empirical evidence of the potential for targeted policies to enhance compliance outcomes. The results underscore the significance of strong regulatory frameworks and effective enforcement mechanisms in regulated industries, especially where violations pose direct public health risks. The demonstrated effectiveness of HR2W offers valuable insights for policymakers considering similar legislative measures to strengthen regulatory oversight and improve compliance with environmental and public health standards.

Despite the robustness of these findings, certain limitations should be acknowledged. First, while the synthetic control method provides a rigorous approach to causal inference, it relies on the assumption that no unobserved factors systematically influenced compliance trends in California after 2016. Although robustness tests support HR2W as the primary driver of improved compliance, the potential influence of concurrent regulatory measures cannot be entirely excluded. Second, the study focuses exclusively on enforcement priority status as the outcome measure, which reflects regulatory compliance but does not directly measure broader improvements in water quality or public health. Future research could investigate whether the observed compliance improvements translate into tangible enhancements in drinking water quality and health outcomes and whether similar legislative interventions produce comparable effects in other jurisdictions.

Overall, the findings provide compelling evidence that HR2W substantially improved drinking water compliance in California. This policy's success underscores the critical role of regulatory frameworks and enforcement capacity in ensuring safe drinking water. Continued monitoring and sustained regulatory attention will be essential for maintaining these compliance gains and maximizing the long-term public health benefits of HR2W.

References

Abadie, A., A. Diamond, and J. Hainmueller (2010): "Synthetic control methods for comparative case studies: Estimating the effect of California's tobacco control program," *Journal of the American Statistical Association*, 105, 493–505.

California Water Boards (2024): "Failing Water Systems: The Human Right to Water (HR2W) List Criteria," *California State Water Resources Control Board Report*, 2024.

Earnhart, D. H. and R. L. Glicksman (2015): "Coercive vs. cooperative enforcement: Effect of enforcement approach on environmental management," *International Review of Law and Economics*, 42, 135–146.

Elbakidze, L. and Q. Beeson (2021): "State regulatory heterogeneity and compliance with the clean water and safe drinking water acts," *Water Resources Research*, 57, e2020WR028952.

EPA (2025): "Enforcement and compliance history online: Drinking Water Dashboard Help," Accessed: 2025-02-25.

EPA (2025): "Enforcement and compliance history online: EPA/State Drinking Water Dashboard," Accessed: 2025-02-25.

EPA (2025): "Variances and Exemptions under the Safe Drinking Water Act," Accessed: 2025-02-25.

Gray, W. B. and J. P. Shimshack (2011): "The effectiveness of environmental monitoring and enforcement: A review of the empirical evidence," *Review of Environmental Economics and Policy*.

Harrington, W. (1988): "Enforcement leverage when penalties are restricted," *Journal of Public Economics*, 37, 29–53.

River Network (2025): "State Policy Hub: Drinking Water," Accessed: 2025-02-25.

Sappington, D. E. M. (1991): "Incentives in principal-agent relationships," *Journal of economic Perspectives*, 5, 45–66.

U.S. BEA (2025): "Regional Data: GDP and Personal Income by State," Accessed: 2025-02-25.

Appendix

State	Policy	Date	Description
Alaska	AK H 209	07.28.2016	committee studies rural water and sewer needs
Arizona	HB 2049	04.28.2017	expands grant eligibility for small water systems
	SB 1459	05.12.2016	assist low-income homeowners with well improvements
Colorado	HB 1306	06.08.2017	funds lead testing in public schools
	HB 20-1119	06.29.2020	regulates PFAS storage, disposal, and firefighting foam
	SB 20-2018	06.29.2020	establishes PFAS fund for grants, takeback, and assistance
	HB 22-1358	06.07.2022	law mandates lead testing in schools, childcare
Connecticut	HB 5509	06.14.2018	protects vulnerable groups from sewer foreclosures
Delaware	HB 200	07.22.2021	funds clean water projects, prioritizing equity
Illinois	SB 550	01.17.2017	mandates lead testing, inventory, and notification
	SB 2146	08.23.2019	invests in clean water infrastructure and workforce training
	HB 0414	08.06.2021	creates low-income water and sewer assistance program
	HB 3739	01.01.2022	mandates full lead pipe replacement and assistance
Indiana	HB 1138	05.01.2023	preschools and childcare must test for lead
Kentucky	SB 409	04.26.2000	expands water access and regionalization efforts
Maine	S.P. 64	06.21.2021	mandates PFAS monitoring, notification, and mitigation
	HP 113	07.15.2021	nation's first comprehensive PFAS product ban enacted
Maryland	SB 96	04.30.2019	prohibits tax sales for water bill liens
Michigan	HB 4342	10.24.2023	child care centers must label water safety
	SB 88	10.24.2023	child care centers must manage lead exposure
Minnesota	HF 1	10.21.2020	funds water infrastructure upgrades and protection
	HF 2310	05.24.2023	funds PFAS mitigation, bans, and regulations
New Hampshire	SB 309	07.10.2018	sets PFAS water standards, adds toxicologist
	HB 1264	07.23.2020	sets PFAS MCLs, funds programs, expands standards
New Jersey	SB 968/A2863	05.11.2021	law mandates lead level notifications quickly
	SB 994	09.13.2022	mandates utility affordability
New Mexico	SB 1	03.13.2023	facilitates regionalization of water utilities
New York	SB S8158	09.06.2016	schools must test for lead, provide aid
	VolA-5-5-1	08.26.2020	sets maximum contaminant levels for contaminants

State	Policy	Date	Description
North Carolina	HB 1087	07.01.2020	funds utilities, reviews, mergers, and projects
Ohio	HB 512	09.09.2016	strengthens Lead and copper testing requirement
	3745-81-84	05.01.2018	revised Lead and Copper Rule
	HB 166	11.01.2019	H2Ohio fund for water quality projects
Oregon	Water Vision	2019	improvements to our infrastructure and ecosystems
Rhode Island	SB 2298	06.24.2022	mandates PFAS testing, standards, and monitoring
	SB 0724	06.22.2023	revises PFAS contamination response
Vermont	Act 21	05.15.2019	regulation of poly-fluoroalkyl substances
	Act 139	07.06.2020	construction grants for public water improvement
Virginia	HJ538	02.24.2021	access to clean, potable, and affordable water
	HB 1257	01.01.2022	sets maximum contaminant levels
Washington	SB 6413	06.07.2018	bans PFAS firefighting foam, mandates disclosure
	SB 5135	07.28.2019	regulates priority toxic chemicals in products
Wisconsin	SB 48	02.21.2018	enables utilities to fund lead pipe replacements

Table A1: States Excluded from Analysis Due to Policy Interventions (2016–2023). HF: House File, HB: House Bill, SB: Senate Bill, PFAS: Perfluoroalkyl and Polyfluoroalkyl Substances. Data Source: River Network 2025, retrieved on February 25, 2025.

Treatment Group	**Control Group (26)**
California	Alabama, Arkansas, DC, Florida, Georgia, Hawaii, Idaho, Iowa, Kansas, Louisiana, Massachusetts, Mississippi, Missouri, Montana, Nebraska, Nevada, North Dakota, Oklahoma, Pennsylvania, South Carolina, South Dakota, Tennessee, Texas, Utah, West Virginia, Wisconsin

Table A2: Treatment Group and Control Group States