Understanding Disparities in Punishment: Regulator Preferences and Expertise

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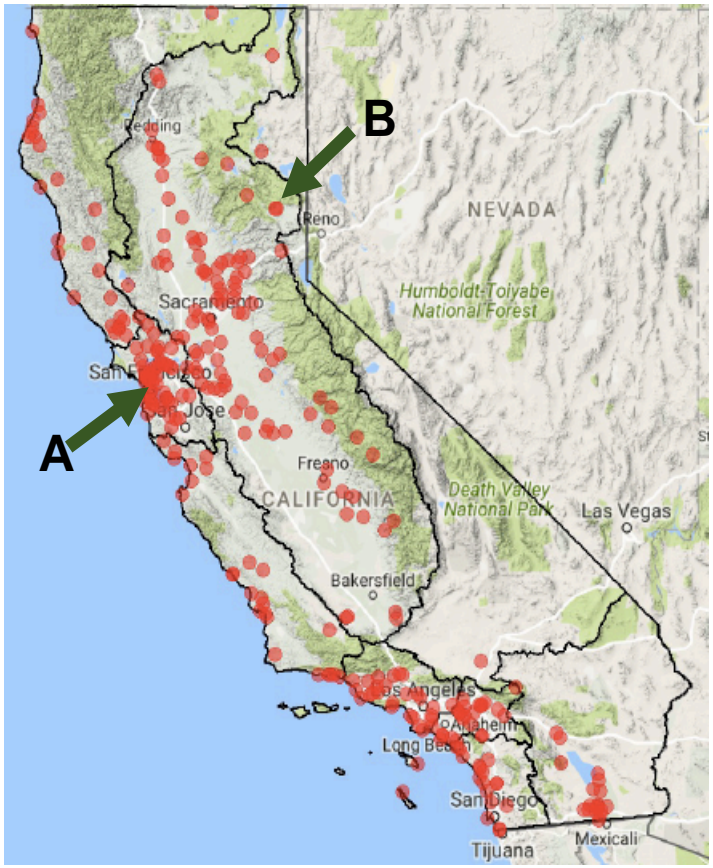
  - Pros: Regulators' information or expertise used for an efficient allocation of enforcement resources
  - Cons: Regulators' private interests not representing public interests, possibly driven by capture, corruption, or lack of dedication
- This paper presents a framework for evaluating regulatory discretion
  - Context: Enforcement of the Clean Water Act in California, focusing on wastewater treatment facilities (73% of violations)

Motivation



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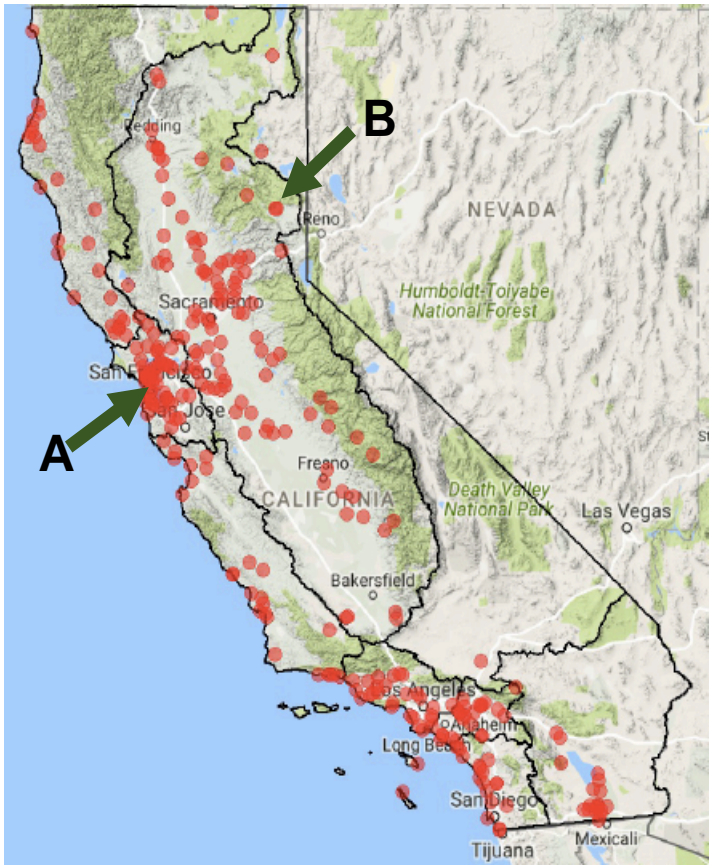

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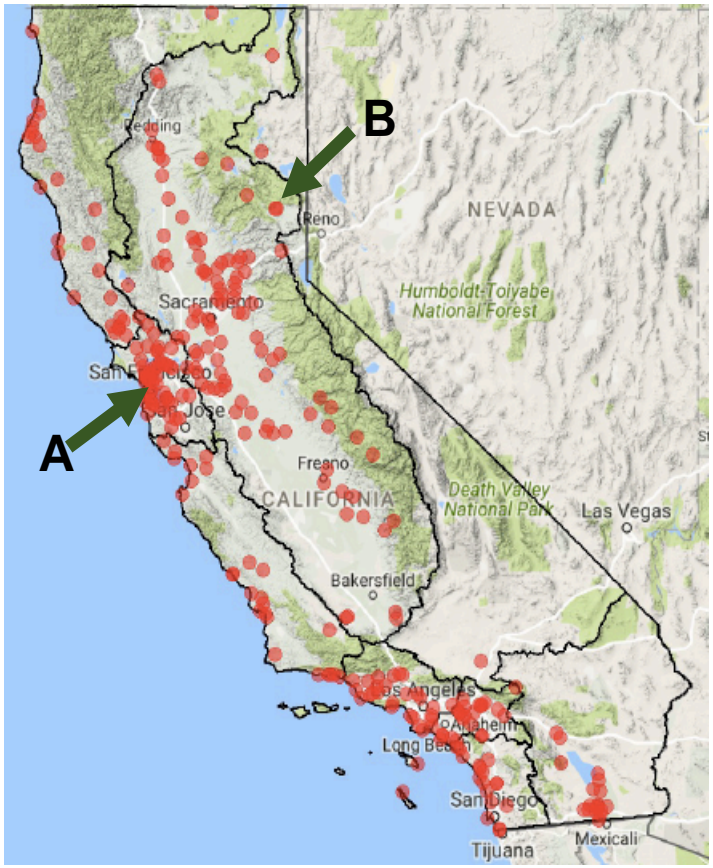

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1. Larger external costs
2. Smaller enforcement costs

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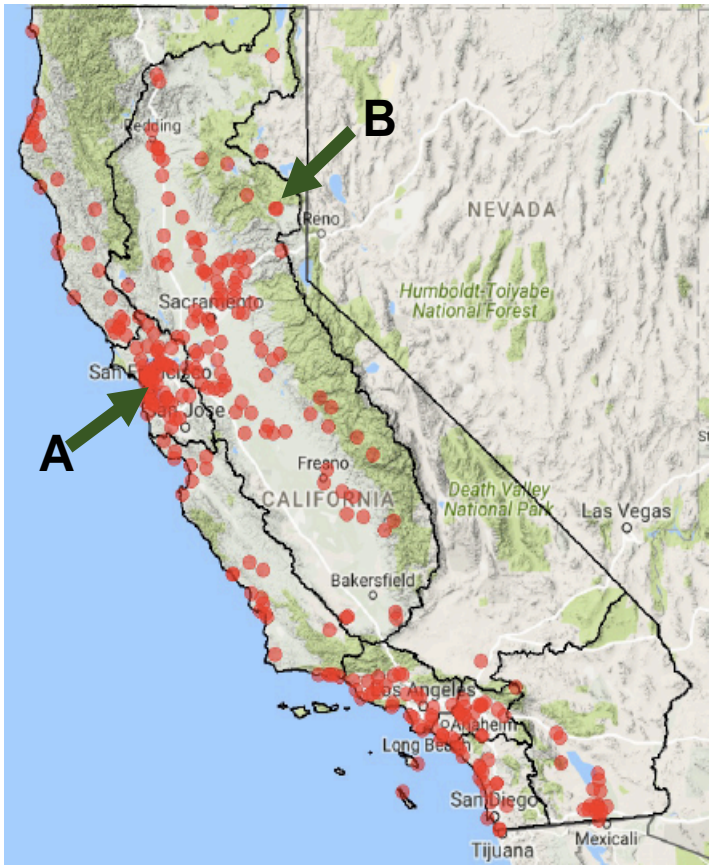

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2. Smaller enforcement costs
3. Higher compliance cost

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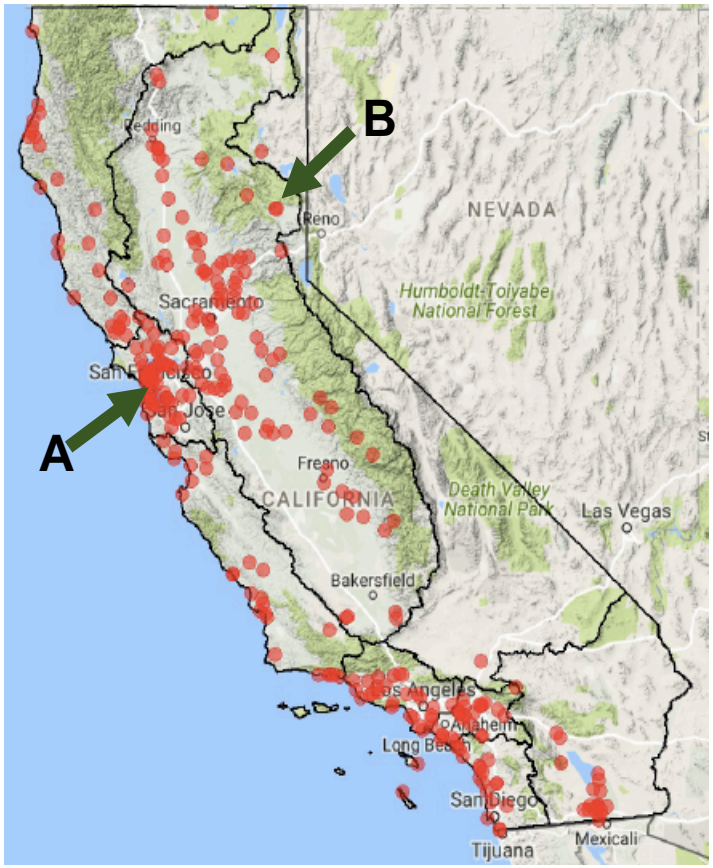

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2. Smaller enforcement costs
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4. Other violations

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- Sources of penalty disparities:
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- **Q1**: Do regulator preferences reflect local residents' preferences?
- **Q2**: To what extent does the variation in regulator preferences explain penalty disparities?
- **Q3**: What if we limit regulatory discretion, by mandating a one-size-fits-all policy or a constant per-violation penalty?

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4. Estimate the model and conduct counterfactual analyses

Preview of Findings

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1. Regulators tailor penalties to local residents' preferences
2. Variation in regulator preferences is not the main driver of the observed penalty disparities
3. Limiting regulatory discretion would raise enforcement costs, and increase violations by facilities with relatively high benefits of compliance

Literature Review

- Empirical studies on bureaucrats/regulatory mechanisms: Cropper et al (1992), Leaver (2009), Agarwal, Lucca & Trebbi (2014), Kang & Miller (2017), Duflo, Greenstone, Pande & Ryan (2018), Blundell, Gowrisankaran & Langer (2019)
- Structural empirical analyses on regulation under asymmetric information: Wolak (1994), Thomas (1995), Timmins (2002), Gagnepain & Ivaldi (2002), Brocas, Chan & Perrigne (2006), Ryan (2012), Gagnepain, Ivaldi & Martimort (2013), Oliva (2015), Fowlie, Reguant and Ryan (2016), Lim & Yurukoglu (2018), Abito (forthcoming)

Today's Talk

1. Penalty disparities: Institution and evidence
2. Model of optimal regulation enforcement
3. Identification and estimation of the model
4. Estimation results and counterfactual analyses

Water Discharge Regulation

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- Wastewater treatment facilities: Violations often due to improper operation/maintenance (as opposed to capital investment)

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- Regional water boards perform most enforcement
  - 7 board members serving 4-year terms, appointed by the governor and confirmed by the State Senate
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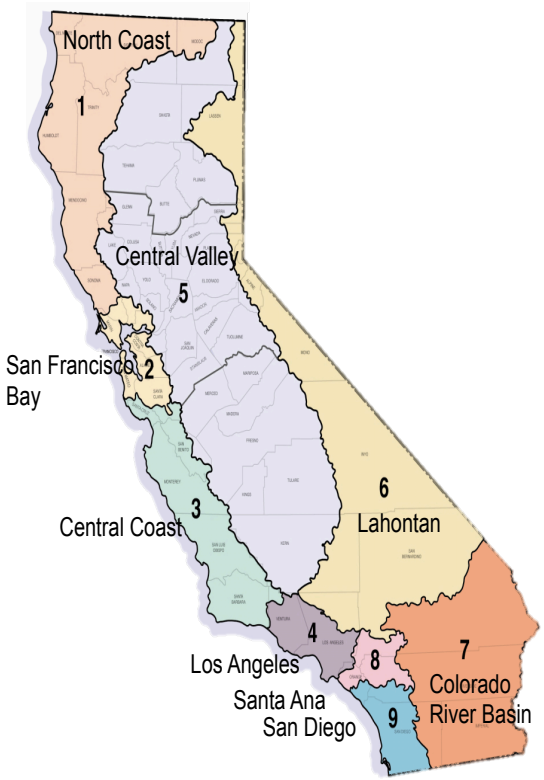
- Recent policy proposals to reduce the autonomy of the regional water boards

Regional Water Boards



- Divided by watersheds (not political boundaries)
- Water pollution problems are regional
- Local preferences differ:
  - Income, population density, political views
  - Industry composition and water use, water quality

Determination of Penalties

- When a violation is identified and confirmed
  1. Administrative civil liability (ACL) can be issued
  2. Violator may pay the liability or dispute the ACL
- Penalty amount in an ACL is based on
  - Initial amount based on the violation's extent/severity, sensitivity of the receiving water, harm to the beneficial water uses
  - Adjustments based on the violator's conduct and financial ability, etc.
  - Mandatory minimum penalty (MMP) for serious/chronic violations
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  - Mandatory minimum penalty (MMP) for serious/chronic violations
  - Final modifications by the board members
- Discretion in defining and quantifying each factor

Data

- 228 domestic wastewater treatment facilities; 2000–2014
- Compliance and enforcement: California Integrated Water Quality System database (CIWQS)
- Wastewater treatment facility attributes: CIWQS and Clean Watersheds Needs Survey
- County-level attributes: American Community Survey (income), Census (population size; water use), California Irrigation Management Information System (weather), California Secretary of State (vote shares for propositions)
- Water pollution: STORET and National Water Information System

Determination of Penalties in the Data

- Unique data that links each violation record to its corresponding penalty

$$\begin{aligned} Log(Penalty_{vft} + 1) &= \alpha Violation\ Attributes_{vft} + \beta Other\ Violations_{ft} \\ &+ \gamma Facility\ \&\ Local\ Attributes_{ft} + \phi_t + \epsilon_{vft} \end{aligned}$$

- Disparities in penalty: Variations in penalty *controlling for violation attributes*
  - $\beta \neq 0$? : Nonlinear penalty; Dynamic enforcement
  - $\gamma \neq 0$? : Regulator preferences; Compliance cost differences

Determination of Penalties in the Data

Dependent var: $Log(Penalty + 1)$	(1)	(2)	(3)
Any other current violations	0.599**	0.779***	0.817***
Any past violations (6 mo)	-0.068	0.012	0.430
Major facility		1.402***	0.692
Started in 1982-87		1.616**	1.267***
Started in 1988-		1.492	0.164
Special district		1.014**	0.817**
Irrigation water use >67%			1.119*
Household income >$57K			1.133*
Prop. approval >50%			1.015**
Violation attributes	Yes	Yes	Yes
Adjusted R^2	0.174	0.245	0.406

Notes: 15,827 violations. SE clustered at the facility level. *0.10,** 0.05,*** 0.01.

- Violation attributes: Priority and pollutants (this table); Emission amount, limit, period, and pollutant (appendix)

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- Nonlinear penalty (larger penalty with other concurrent violations)
- Static enforcement (past violations don't matter)

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- Controlling for violation attributes, major (large) facilities are penalized more; Why?

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- Not only facility attributes, but also local attributes matter; Why?

Revisit the Agenda

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- Facility knows its type, but regulator only knows $\Theta \sim F(\cdot)$
- Regulator sets penalty schedule depending on k, $\overline{\epsilon}(k)$
  - Expected penalty at negligence a: $e(a) \equiv \sum_{k \in \mathbb{N}} \overline{\epsilon}(k) \frac{a^k e^{-a}}{k!}$

Model: Setup (2/3)

- Facility takes penalty schedule as given, and maximizes payoff:

$$\max_{a} \ \theta b(a) - e(a)$$

Facility's FOC:

$$\theta b'(a) = e'(a)$$

Model: Setup (3/3)

- Regulator minimizes *total* cost associated with enforcement:

$$\min_{e(\cdot)} \int_0^{\overline{\theta}} \Big\{ \underbrace{-\theta b[a(\theta)]}_{\textit{compliance cost}} + \underbrace{\gamma a(\theta)}_{\textit{environmental cost}} + \underbrace{\psi e[a(\theta)]}_{\textit{enforcement cost}} \Big\} \underbrace{f(\theta)}_{\textit{type dist.}} d\theta$$

subject to

1. Incentive compatibility: $a(\cdot)$ maximizes facility payoff under $e(\cdot)$
2. Limited liability: $e(\cdot)$ is less than maximal penalty
3. Nonnegative penalty: $e(\cdot) \geq 0$

Model: Equilibrium

- Proposition 1 characterizes equilibrium
  - Regulator's FOC:

$$b'[a(\theta)]\left(\theta + \frac{\psi[1-F(\theta)]}{(1-\psi)f(\theta)}\right) = \frac{\gamma}{1-\psi}$$

  - Under standard conditions, optimal $a(\cdot)$ is continuous and *strictly increasing* for any θ with $a(\theta) > 0$

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Identification Problem

Model Primitives	Observables
For each facility:	For each facility and period:
$F(\cdot)$: Distribution of types	Number of violations
$b(\cdot)$: Compliance cost	Penalty for each violation
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- We exploit changes in enforcement practices in 2006:
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Model Primitives	Observables
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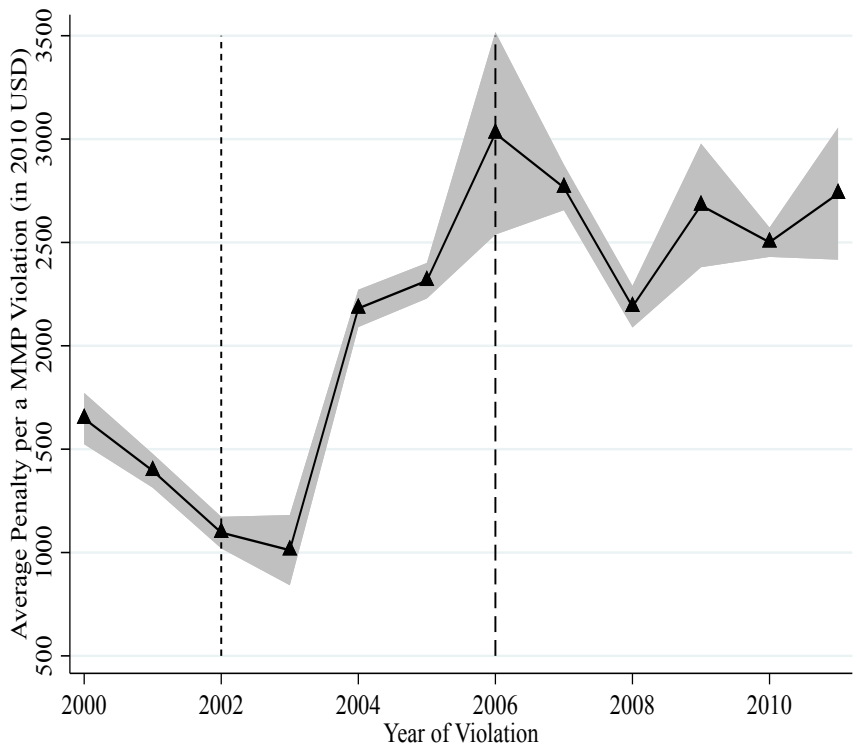
γ and ψ (pre & post 2006)	

- Exogenous variation in penalties allows us to identify facilities' costs without relying on regulator optimality
- We exploit changes in enforcement practices in 2006:
  - Data system for electronic submittal/review of self-reports
  - Established the Office of Enforcement
- Exclusion restriction: The 2006 changes affected (γ, ψ) only

Institutional Changes Led to Penalty Increases

Average Penalty per Violation

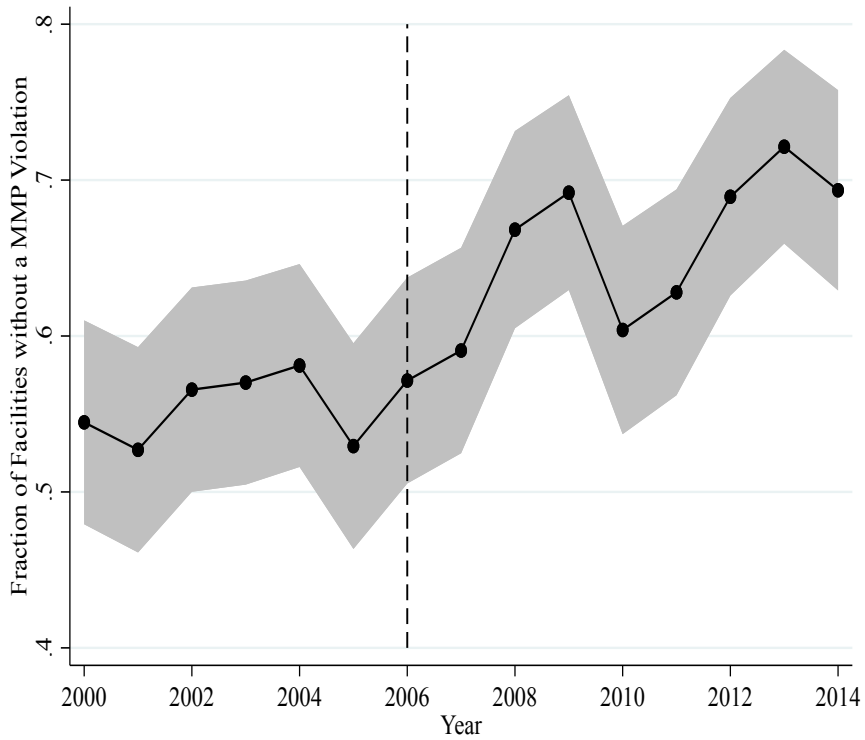


Based on the CWIQ database regarding all wastewater treatment facilities; 95% CI in shaded area

- Average penalty per *MMP violation* within 4 years of violation
- 2006 institutional changes affect violations from 2002 on

Institutional Changes Led to Compliance Increases

Fraction of Facilities in Compliance



Based on the CWIQ database regarding all wastewater treatment facilities; 95% CI in shaded area

- Fraction of facilities without a MMP violation per year
- Compliance rate increase after 2006
- Facilities responded to penalty increase

Identification Strategy: Overview (1/2)

- Identify compliance cost function and type distribution $(b(\cdot), F(\cdot))$
  - Exploit facilities' responses to 2006 changes (D'Hautfoeuille & Février, *forthcoming*)
- Identify regulator preference weights $(\psi_{pre}, \psi_{post}, \gamma_{pre}, \gamma_{post})$ from regulator's FOC (Luo, Perrigne & Vuong, 2018)

Identification Strategy: Overview (2/2)

- Identification argument is for each facility: Suppose we have enough observations for any given facility to obtain
  1. Distribution of its number of violations
  2. Penalty as a function of its number of violations per period

  Then all primitives can be identified for each facility
- In reality, our sample is not large enough: We estimate the primitives of the model *conditional on observed facility attributes*

Sketch of Identification Proof: Step 1

For each facility, identify the following equilibrium objects:

1. Distributions of negligence level (a), pre/post 2006
   - Distribution of the number of violations (k) is observed
   - Distribution of a is identified from the distribution of k (Aryal, Perrigne & Vuong, 2019)
2. Penalty schedules, pre/post 2006
   - Penalty schedules as a function of the number of violations: Directly observed from the data
   - Penalty schedules as a function of negligence level (a): Calculated given the assumption that the number of violations (k) follows $Poisson(a)$

Sketch of Identification Proof: Step 2

Identify the equilibrium negligence functions evaluated at finite θ points:

1. Start with $\theta_0 = 1$ and $a_{post}(\theta_0) = 1$ (normalization)
2. Solve for $a_{pre}(\theta_0)$: (i) a is strictly increasing, and (ii) $F(\cdot)$ and $b(\cdot)$ invariant:

$$a_{pre}(\theta_0) = G_{pre}^{-1}\left(G_{post}[a_{post}(\theta_0)]\right)$$

   * $G_{pre}(\cdot)$, $G_{post}(\cdot)$: CDF's of negligence level (a) (*identified in Step 1*)

3. Pick θ_1 so that $a_{post}(\theta_1) = a_{pre}(\theta_0)$ from the facility FOC, $\theta b'(a) = e'(a)$:

$$\theta_1 = \frac{e'_{post}[a_{pre}(\theta_0)]}{e'_{pre}[a_{pre}(\theta_0)]}\theta_0$$

   * $e_{pre}(\cdot)$, $e_{post}(\cdot)$: Penalty schedules (*identified in Step 1*)

Sketch of Identification Proof: Step 2 (Illustration)

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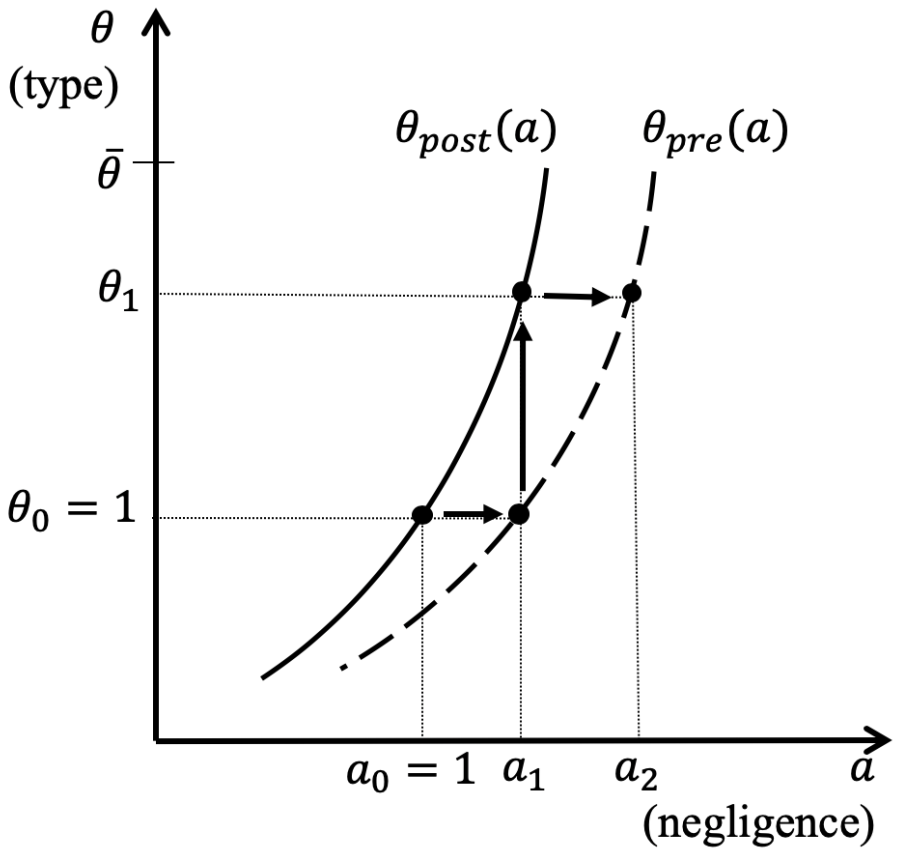

$$T^H(a) = G_{pre}^{-1}[G_{post}(a)]$$

$$T^V(\theta, a) = \frac{e_{post}'(a)}{e_{pre}'(a)}\theta$$

Sketch of Identification Proof: Step 3

Identify cost type distribution, $F(\cdot)$, and marginal base compliance cost function, $b'(\cdot)$, evaluated at finite points:

- With two different regimes (pre and post 2006), we partially identify compliance costs by exploiting facilities' optimality
- $F(\theta_\ell)$ from the monotonicity of $a(\cdot)$:

$$F(\theta_\ell) = G_{pre}[a_{pre}(\theta_\ell)] = G_{post}[a_{post}(\theta_\ell)]$$

  * $G_{pre}(\cdot)$, $G_{post}(\cdot)$: CDF's of negligence level (a) (*identified in Step 1*)

- $b'[a_{pre}(\theta_\ell)]$ and $b'[a_{post}(\theta_\ell)]$ from the facility FOC:

$$\theta_\ell b'[a_{pre}(\theta_\ell)] = e'[a_{pre}(\theta_\ell)]$$

Sketch of Identification Proof: Step 4

Identify regulator preferences $(\psi_{pre}, \psi_{post}, \gamma_{pre}, \gamma_{post})$ and compliance costs

- Regulator preferences from the regulator FOC for $j = pre, post$:

$$b'[a_j(\theta)]\left(\theta + \frac{\psi_j[1 - F(\theta)]}{(1-\psi_j)f(\theta)}\right) = \frac{\gamma_j}{1-\psi_j}$$

  1. $\{\theta_\ell, a_j(\theta_\ell), F(\theta_\ell), b'[a_j(\theta_\ell)]\}$'s identified from Steps 2 & 3
  2. Rewrite the FOC using the relationship between density and quantile function, i.e., $f[Q(\alpha)] = 1/Q'(\alpha)$

- Fully identify $F(\cdot)$ and $b'(\cdot)$ from regulator and facility FOC's

Multi-step Estimation

1. Parametrically estimate (1) the distributions of violations and (2) the enforcement schedules, before and after the 2006 changes, as functions of facility and local attributes ($\mathbf{x}_{i,t}$)
   - $\mathbf{x}_{i,t}$: Facility i's age, size, treatment technology, capacity utilization, threat to water quality, county characteristics (income, population density, vote share for 2006 Proposition 84), water pollution, weather, and region dummies in period t
2. Estimate $\psi_{pre}(\mathbf{x})$, $\psi_{post}(\mathbf{x})$, $\gamma_{pre(\mathbf{x})}$,$\gamma_{post}(\mathbf{x})$, $b'(\cdot|\mathbf{x})$, and $F(\cdot|\mathbf{x})$ for any $\mathbf{x}$, without any further functional form assumptions, following the proof of the identification

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Regulator's vs. Local Constituents' Preferences

Recall:

$$\int_0^{\overline{\theta}} \left\{ \underbrace{-\theta b[a(\theta)]}_{\textit{compliance cost}} + \underbrace{\gamma a(\theta)}_{\textit{environmental cost}} + \underbrace{\psi e[a(\theta)]}_{\textit{enforcement cost}} \right\} \underbrace{f(\theta)}_{\textit{type dist.}} \, d\theta$$

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- γ_{pre} is 47% higher for a facility in a high-income county
- ψ_{pre} is 29% lower for a facility in a high-income county

Regulator's vs. Local Constituents' Preferences

Recall:

$$\int_0^{\overline{\theta}} \Big\{ \underbrace{-\theta b[a(\theta)]}_{\textit{compliance cost}} + \underbrace{\gamma a(\theta)}_{\textit{environmental cost}} + \underbrace{\psi e[a(\theta)]}_{\textit{enforcement cost}} \Big\} \underbrace{f(\theta)}_{\textit{type dist.}} \, d\theta$$

- γ_{pre} is 47% higher for a facility in a high-income county
- ψ_{pre} is 29% lower for a facility in a high-income county
- ψ_{pre} is 13% lower for a facility in a county supporting the 2006 Proposition 84

Regulator's Preferences and Penalty Disparities

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To assess extent to which heterogeneity in regulator preferences explains disparities in penalties:

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- Compare the dispersion of penalty schedules under the current and the alternative scenarios
- Findings:
  - SD in the penalty stringency across the facilities: Decrease by 11%
  - 5th-95th percentile range in the expected penalties: Decrease by 16–28% (depending on the compliance level)

Limiting Regulatory Discretion (1/3)

- Key patterns in the data
  1. Penalty stringency vary with facility/local attributes
  2. Nonlinear (convex) penalty in violation frequency

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  - Consistent with Duflo, Greenstone, Pande and Ryan (2018)
- Who would violate more under the uniform policy? Large; posing a high threat to water quality; located in a high-income area

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- Convex penalties imply larger penalties per violation to facilities with relatively high compliance costs
- High-cost facilities violate more, and others less
- Value of discretion: Linear penalty that achieve the same violation frequency as in the baseline scenario would raise penalties by 12%
  - Consistent with Blundell, Gowrisankaran and Langer (2019)

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- Policies that restrict regulatory discretion are sub-optimal because
  - Regulator cannot utilize her knowledge and expertise on facilities' compliance costs to efficiently allocate enforcement resources
  - Local residents' preferences may not be well-represented
- But, with discretion, regulators may put forward their private interests (corruption, lack of dedication, etc.)
- Without estimates on the social benefits of compliance, we provide an *upper* bound on the *excess* expected number of violations associated with regulators' private interests
  - Under a *green* regulator, violations would decrease by half with a 77% increase of penalties

Conclusion

- Provide an empirical framework to evaluate regulatory discretion
  - Consider an adverse selection model of regulation enforcement
  - Identify and estimate discharger costs and regulator preferences
  - Apply to California water quality regulation
- Regulator preferences vary across facilities, but
  - They reflect local residents' preferences
  - The variation in regulator preferences is not the main driver of penalty
- Limiting regulatory discretion raise enforcement costs and increase violations by facilities with relatively high benefits of compliance