Strategic Local Regulators and the Efficacy of Uniform Pollution Standards

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Motivation

- Local air quality depends on local regulators' efforts in regulating industry emissions.
- Federal EPA determines local violation status based on local monitor readings
- Violations to the national standard are subject to punishments on both local regulators and local economy (i.e., new pollution source review program, state implementation plan, withholding federal highway funding).
- After the revision of the $PM_{2.5}$ national standard (NAAQS) in 2006
  - there are initially 208 non-attainment counties
  - 5 years later, only 17 counties switched to attainment

Research Question

- Is a universal national air quality standard always effective, given that local jurisdictions control the investment of local regulation resources?
- How does a local regulator allocate investment of local regulation resources?
- How does the allocation of local regulation resources change in response to more stringent national standards?

Economic Intuition

Local regulator's objective is to minimize:

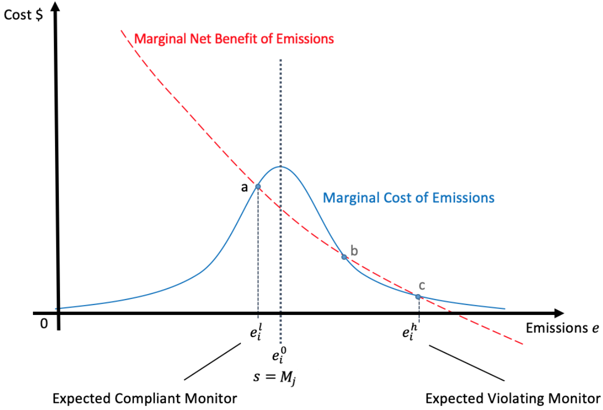
Total Cost = *Indirect Regulation Cost* + *Expected Cost of Pollution Damage* + *Expected Violation Penalties*

More plant-specific regulation resources from the local regulator means

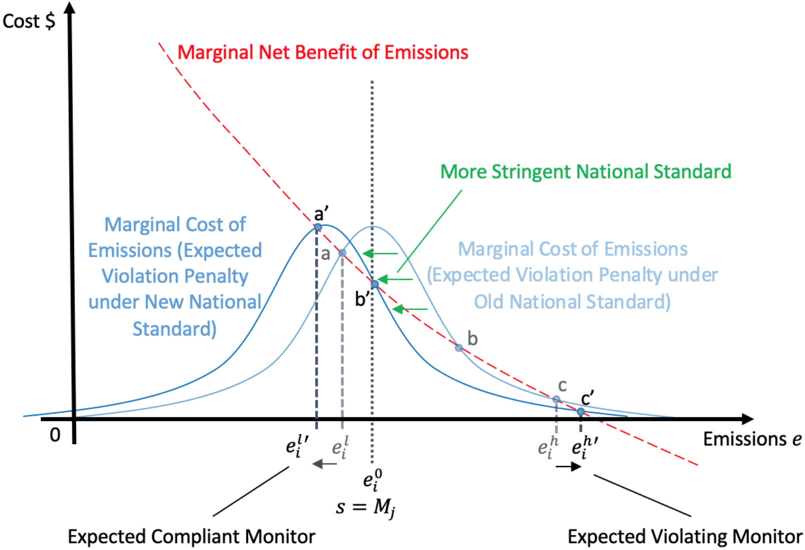
- Higher direct regulation cost
- Less plant emissions ➔ Lower cost of pollution damage
- Lower expected monitor readings ➔ Lower probability of violation, lower expected violation penalties

Local Regulator's Problem

- Marginal Net Benefit of Emissions = Avoided marginal Direct Regulation Cost - Marginal Pollution Damage
- Marginal Cost of Emissions = Marginal Expected Violation Penalties



Local Regulator's Response to More Stringent National Standard

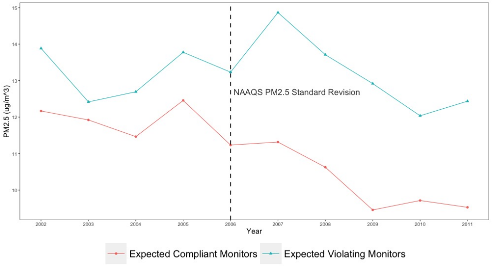


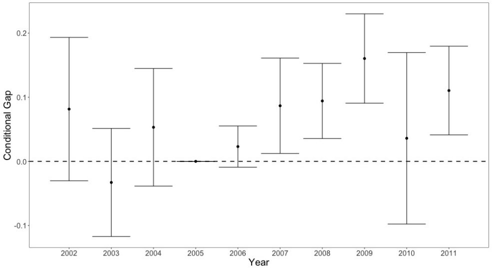
Empirical Analysis: Monitor Level Analysis

U.S. EPA changed NAAQS "PM$_{2.5}$ 24-hour Standard" from 65 $\mu g/m^3$ in 1997 to 35 $\mu g/m^3$ in 2006

- Monitor-by-Year data
  - 994 continuous monitors, active both before and after (including) 2006
  - 128 "Expected Violating Monitors": never complied after the revision (2007-2011)
  - 866 "Expected Compliant Monitors": complied for at least one year after revision (2007-2011)
  - Non-continuous (temporarily active) monitors are excluded from the monitor level analysis

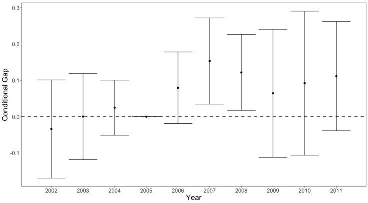
Empirical Analysis: Monitor Level Analysis



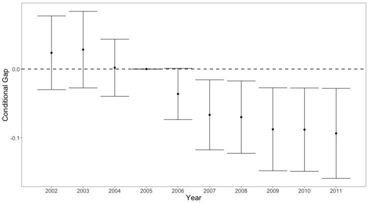


Empirical Analysis: Plant Level Analysis

- Plant-by-Year data
  - 33,848 plants from TRI
  - Greenstone (2002): map TRI chemicals to particulate matter
  - Compare plants near "Expected Violating Monitors" (793 plants) and plants near "Expected Compliant Monitors" (5,681 plants) with "Control Plants" (27,374 plants)
  - Here, "near" is defined by arbitrary distance threshold at 5KM



(a) Plants near "Expected Violating Monitors"



(b) Plants near "Expected Compliant Monitors"

Conclusion

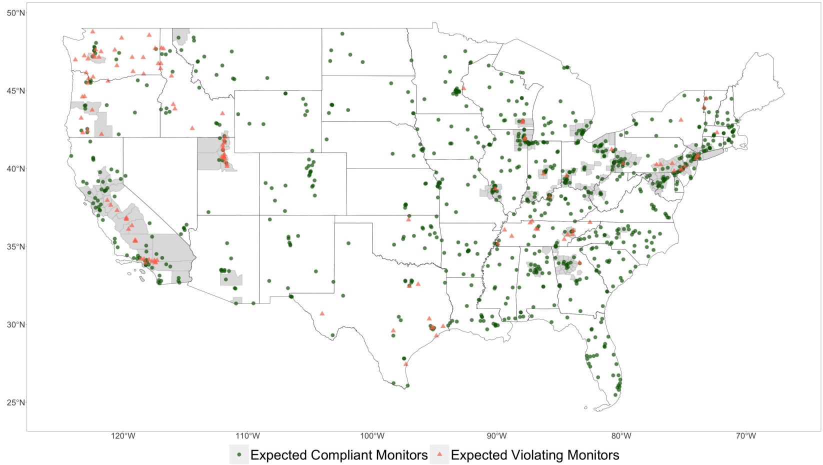
- We propose a theoretical model to describe the strategic behavior of local regulators.
- Our theory suggests that when the national pollution standard is too expensive to comply with, local regulators may intentionally violate it.
- Instead of a universal national standard, it might be better to customize more achievable pollution standards for each area to avoid the intentional violation.

Questions, Comments and Suggestions

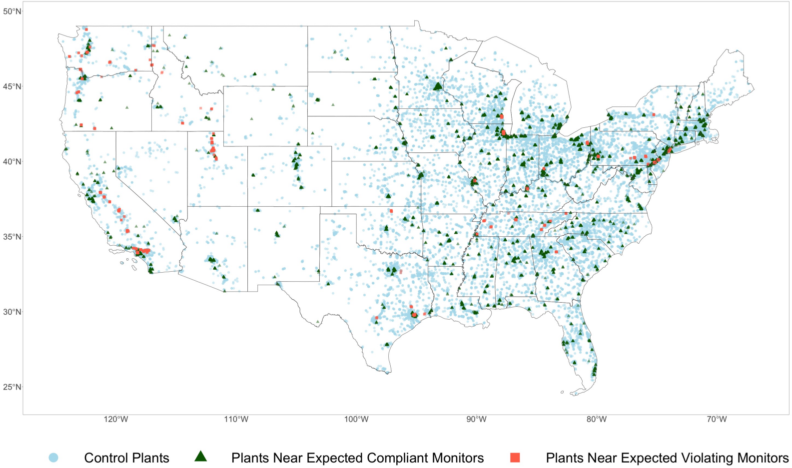
Thank you!

- Email: ruohao.zhang@kellogg.northwestern.edu
- Working paper is available on my personal website: https://ruohaozhang.weebly.com/publications--working-papers.html

Monitor Map


50°N
45°N
40°N
35°N
30°N
25°N
120°W
110°W
100°W
90°W
80°W
70°W
Expected Compliant Monitors
Expected Violating Monitors

Plant Map



50°N
45°N
40°N
35°N
30°N
25°N
120°W
110°W
100°W
90°W
80°W
70°W
Control Plants
Plants Near Expected Compliant Monitors
Plants Near Expected Violating Monitors

Monitor Readings

$$m_j = \beta X_j + \sum_{i \in I_j} f(d_{ij}) e_i + u_j, \tag{1}$$

m_j: readings of monitor J, captures the emissions from

- Local industry
- Other unregulated background economic activities (such as traffic and unregulated residential/commercial fuel combustion)

I_j: Industrial plants located near monitor j

e_i: emissions from plant i

d_{ij}: Distance between plant i and monitor j

u_j: Random component

Local Regulator's Problem: Expected Violation Penalty

Let s be the national standard, K is a fixed violation penalty,

- Violation if $m_j > s$
- Compliance if $m_j \leq s$

Expected monitor reading:

$$M_j = \beta X_j + \sum_{i \in I_j} f(d_{ij}) e_i \tag{2}$$

Expected violation penalty:

$$\Big(1 - Pr(m_j \leq s)\Big)K = (1 - Pr(\beta X_j + \sum_{i \in I_j} f(d_{ij}) e_i + u_j \leq s)\Big)K \tag{3}$$

Local Regulator's Problem: Other Costs

Local regulator determines the regulation resources on each plant i to reduce the plant emissions e_i

- Lower e_i requires more regulation resources
- Indirect regulation cost on plant i: $C(e_i, \theta_i)$, decrease in e_i
- θ_i is the plant characteristics

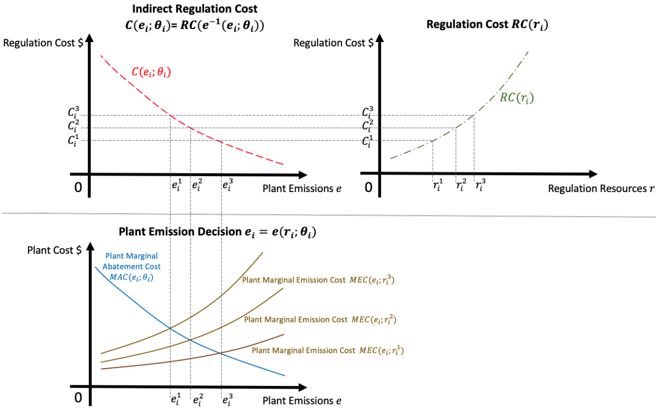
Plant i's emissions e_i also cause local welfare loss

- Expected cost of pollution damage: $G\big(M_j; \sigma_j\big)$, increase in M_j
- σ_j is the socio-economic characteristics of the neighborhood around monitor j

$$
\begin{aligned}
\underset{e_i|i \in I_j}{min} \; & \sum_{i \in I_j} C(e_i; \theta_i) + G\big(M_j; \sigma_j\big) + \Big(1 - Pr(m_j \leq s)\Big)K \\
= & \sum_{i \in I_j} C(e_i, \theta_i) + G\big(\beta X_j + \sum_{i \in I_j} f(d_{ij}) e_i; \sigma_j\big) \\
& + \Big(1 - Pr(\beta X_j + \sum_{i \in I_j} f(d_{ij}) e_i + u_j \leq s)\Big)K.
\end{aligned} \tag{4}
$$

Indirect Regulation Cost

Indirect regulation cost function $C(e_i, \theta_i)$ is defined according to a one-to-one monotonic mapping between plant optimal emissions e_i to plant-specific regulation cost.



Empirical Analysis: Monitor Level Analysis

Table 3: Monitor Level Analysis: Difference-in-differences Results

	Outcome Variable: *log*(annual $PM_{2.5}$ monitor readings, $\mu g/m^3$)			
Independent Variables	(1)	(2)	(3)	(4)
Revision × Expected Violating	0.190***	0.080**	0.181***	0.078**
	(0.055)	(0.037)	(0.051)	(0.037)
Expected Violating Monitors	0.077	0.144	0.067	0.146
	(0.117)	(0.113)	(0.117)	(0.113)
Population Density (100 people per KM^2)			0.004*	−0.003
			(0.002)	(0.024)
Income per Capita ($1,000)			−0.002	−0.001
			(0.002)	(0.001)
GDP per Capita ($1,000)			0.0002	0.002**
			(0.001)	(0.001)
County FE	N	Y	N	Y
Year FE	Y	Y	Y	Y
R^2	0.110	0.819	0.132	0.819
Adjusted R^2	0.109	0.801	0.131	0.802
Sample size	7,395	7,395	7,347	7,347

Note: Standard errors are clustered at the state level. There are fewer observations in column (3) and (4) because of missing social-economic variables for some counties. Significance level: *** p< .01, ** p<.05, * p<.1.

Empirical Analysis: Plant Level Analysis

Table 4: Plant Level Analysis: Difference-in-differences Results

	Dependent variable:	
	log(PM + 0.1), PM emissions in lbs.	
	(1)	(2)
Near Expected Violating Monitors × Revision	0.106**	0.106**
	(0.053)	(0.051)
Near Expected Compliant Monitors × Revision	−0.086***	−0.084***
	(0.022)	(0.022)
Non-attainment County		−0.024
		(0.022)
Number of all EPA Inspection		−0.017
		(0.013)
Air Emission Ratio		0.908***
		(0.067)
Population Density (100 people per KM^2)		0.055
		(0.038)
Income per Capita ($1,000)		−0.002
		(0.002)
GDP per Capita ($1,000)		0.002***
		(0.001)
Plant FE	Y	Y
Year FE	Y	Y
Observations	229,436	227,229
R^2	0.891	0.895
Adjusted R^2	0.872	0.877

Note: For dependent variable, we add 0.1 to PM before taking natural logs to avoid losing observations with $PM = 0$. Standard errors are clustered at the state level. There are fewer observations in column (2) because of missing social-economic variables for some counties. Significance level: *** p< .01, ** p<.05, * p<.1.