Strategic Local Regulators and the Efficacy of National 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:

\[ \text{Total Cost} = \text{Direct Regulation Cost} + \text{Cost of Pollution Damage} + \text{Expected Violation Penalties} \]

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 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

Marginal Cost of Emissions (Expected Violation Penalty under New National Standard)

Marginal Benefit of Emissions

More Stringent National Standard

Marginal Cost of Emissions (Expected Violation Penalty under Old National Standard)

Expected Compliant Monitor

Expected Violating Monitor

\[ s = E(m_j) \]

\[ e_i^0 \]

\[ e_i^l \]

\[ e_i^l' \]

\[ e_i^h \]

\[ e_i^h' \]
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
  - 974 continuous monitors, active both before (including) and after 2006
  - 150 “Expected Violating Monitors”: never complied after the revision (2007-2011)
  - 824 “Expected Compliant Monitors”: complied for at least one year after revision (2007-2011)
- Non-continuous monitors are dropped from the monitor level analysis
Empirical Analysis: Monitor Level Analysis

- Expected Compliant Monitors
- Expected Violating Monitors

NAAQS PM2.5 Standard Revision
Empirical Analysis: Plant Level Analysis

- Plant-by-Year data
  - 34,285 plants from TRI
  - Greenstone (2002): map TRI chemicals to particulate matter
  - Compare plants near “Expected Violating Monitors” (922 plants) and plants near “Expected Compliant Monitors” (4,918 plants) with “Control Plants” (28,445 plants)
  - Here, “near” is defined by arbitrary distance threshold at 5KM

(a) Plants near “Expected Violating Monitors”

(b) Plants near “Expected Compliant Monitors”
Empirical Analysis: Plant Level Analysis

- 2006 NAAQS revision officially effective on December 18, 2006. However, it is proposed on January 17th, 2006.
- It is possible that local regulator take actions ahead. Try 2006 as treatment starting year gives following results:

(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 will be available soon on my personal website: https://ruohaozhang.weebly.com
Empirical Analysis: Monitor Level Analysis

- Expected Compliant Monitors
- Expected Violating Monitors
- Temporary Monitors
Monitor Readings

\[ m_j = \beta X_j + \gamma \sum_{i \in I_j} f(d_{ij}) e_i + u_j, \]  

(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:

$$E(m_j) = \beta X_j + \gamma \sum_{i \in I_j} f(d_{ij})e_i$$  \hspace{1cm} (2)

Expected violation penalty:

$$\left(1 - Pr(m_j \leq s)\right)K = \left(1 - Pr(\beta X_j + \sum_{i \in I_j} f(d_{ij})e_i + u_j \leq s)\right)K$$  \hspace{1cm} (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
- Cost of regulation resources on plant $i$: $C(e_i, \theta_i)$, decrease in $e_i$
- $\theta_i$ is the plant characteristics

Plant $i$’s emissions $e_i$ also cause local welfare loss

- Cost of pollution damage: $G(e_i, \sigma_i)$, increase in $e_i$
- $\sigma_i$ is the socio-economic characteristics of the neighborhood around plant $i$

$$\min_{e_i} \sum_{i \in I_j} \left( C(e_i, \theta_i) + G(e_i, \sigma_i) \right) + \left( 1 - Pr(\beta X_j + \sum_{i \in I_j} f(d_{ij}) e_i + u_j \leq s) \right) K.$$  

(4)
Empirical Analysis: Monitor Level Analysis

Table 1: Monitor Level Analysis: Difference-in-differences Results

<table>
<thead>
<tr>
<th>Independent Variables</th>
<th>(1)</th>
<th>(2)</th>
<th>(3)</th>
<th>(4)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Revision × Expected Violating</td>
<td>0.180***</td>
<td>0.088***</td>
<td>0.175***</td>
<td>0.087***</td>
</tr>
<tr>
<td></td>
<td>(0.044)</td>
<td>(0.029)</td>
<td>(0.042)</td>
<td>(0.029)</td>
</tr>
<tr>
<td>Expected Violating Group</td>
<td>0.063</td>
<td>0.109</td>
<td>0.054</td>
<td>0.110</td>
</tr>
<tr>
<td></td>
<td>(0.101)</td>
<td>(0.107)</td>
<td>(0.100)</td>
<td>(0.107)</td>
</tr>
<tr>
<td>Population Density (100 people/KM²)</td>
<td></td>
<td></td>
<td>0.003*</td>
<td>−0.002</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td>(0.002)</td>
<td>(0.023)</td>
</tr>
<tr>
<td>Income per Capita ($1,000)</td>
<td></td>
<td>−0.002</td>
<td>−0.001</td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td>(0.002)</td>
<td>(0.001)</td>
</tr>
<tr>
<td>GDP per Capita ($1,000)</td>
<td></td>
<td></td>
<td></td>
<td>0.0002</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td></td>
<td>(0.001)</td>
</tr>
<tr>
<td>County FE</td>
<td>N</td>
<td>Y</td>
<td>N</td>
<td>Y</td>
</tr>
<tr>
<td>Year FE</td>
<td>Y</td>
<td>Y</td>
<td>Y</td>
<td>Y</td>
</tr>
<tr>
<td>Adjusted R²</td>
<td>0.114</td>
<td>0.798</td>
<td>0.136</td>
<td>0.798</td>
</tr>
<tr>
<td>Sample size</td>
<td>7,295</td>
<td>7,295</td>
<td>7,252</td>
<td>7,252</td>
</tr>
</tbody>
</table>

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