Opening the Brown Box: Production Responses to Environmental Regulation

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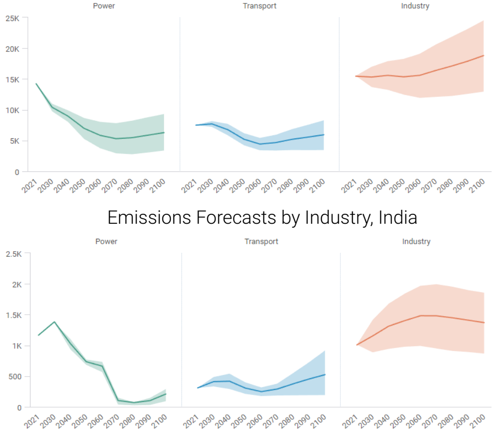
Focus on Reducing Industrial Emissions

- Industrial emissions $\approx \frac{1}{3}$ of total in 2022 (25.8% in India)
- Emissions of other sectors projected to decline, industrial emissions to rise
- Challenges are technological and uncertainty how to design regulation
- Robust evidence targeting firm emissions reduces them
  - → Often by shifting emissions and selling polluting assets
  - → Mixed evidence on firm-level and aggregate effects
  - → No evidence on within-firm production responses

Emissions Forecasts by Industry, Global



Units: Million metric tonnes of CO_2e.
Source: Rhodium Group Climate Deck Database.

This Paper

We combine:

- **Quasi-experiment:** Pollution index introduced in 2009 in India targeting place-based emissions; implementation based on pre-defined thresholds
  - → Difference-in-discontinuity around treatment thresholds
  - → Fixed effects: Firm and State × industry × Year
- **Unique data:** Inside the "brown box" of production processes and on firm outcomes
  - → Product-level inputs and outputs
  - → Abatement expenditures and action plans

Contributions:

- Evidence on firm-level and within-firm production responses
- Evidence on which firms respond and which bear the burden

Results

- Improved pollution metrics at the cluster and product levels
  - → Hand-collect subsequent evaluations conducted by the CPCB
  - → Satellite emissions readings
  - → Product energy inputs and imputed CO_2 emissions
- Treated firms green production —increase in abatement expenditures
  - → Shift from high-emission and coal-dependent products
  - → Electrify production
  - → Abatement investments concentrated where required
  - → Highly-polluting firms bear costs, drive changes
- Highest polluting firms drive results
  - → Average firm maintains profitability
  - → Production changes driven by high-polluting firms, which bear costs
  - → Non high-polluting increase margins
- Firm and regulator actions lower cost, but loss of aggregate dynamism

Contribution to the Literature

- Quantify impact of environmental regulation on emissions
  - → Command-and-control and cap-and-trade policies can both lower targeted emissions (Fowlie, 2010; Harrison et al., 2019; Bartram et al., 2022; Ivanov et al., 2023, ...)
  - → Evidence for shifting emissions (Aichele and Felbermayr, 2015; Schiller, 2018; Ben-David et al., 2021; Dai et al., 2021a and 2021b; Kim and Xu, 2021, ...)
  - → **We focus on industrial clusters and use unique data and identification to study mechanisms**

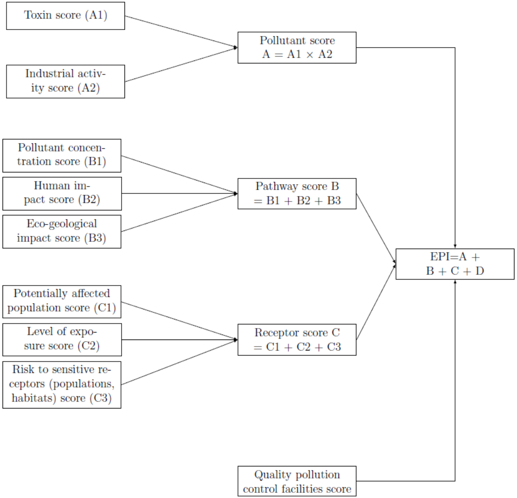
- Impact of emissions regulations on firm outcomes
  - → Mixed evidence on impact on productivity (Duflo et al., 2013; Kalmenovitz and Chen, 2021; Kala and Gechter, 2023, ...) and financial performance (Lenox and Eesley, 2009; Servaes and Tamayo, 2013; Fan et al., 2019; Naaraayanan et al., 2021, ...)
  - → **We document firm-level and within-firm production response**

- Broader literature on how firms impact the environment
  - → Highlighted importance of nature of ownership (Dimson et al., 2015, 2021; Krueger et al., 2020; Naaraayanan et al., 2021; Azar et al., 2021; Atta-Darkua et al., 2023; Berg et al., 2023; Ilhan et al., 2023, ...), disclosures (Jouvenot and Krueger, 2019; Bonetti et al., 2023; Tomar, 2023, ...), financial institutions (Kacperczyk and Peydro, 2022; De Haas, 2023; De Haas and Popov, 2023; Ivanov et al., 2023, ...), and self-commitment (Dahlmann et al., 2019; Comello et al., 2021; Freiberg et al., 2021; Duchin et al., 2022; Bolton and Kacperczyk, 2023, ...), trade (Barrows and Ollivier 2021)

INSTITUTIONAL BACKGROUND

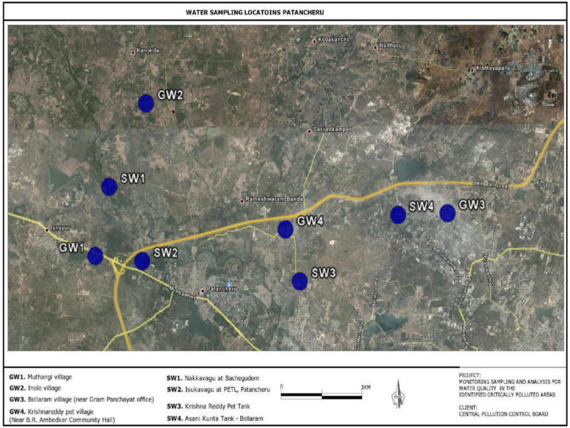
Comprehensive Environmental Pollution Index (CEPI)

Methodology and Assessment



Comprehensive Environmental Pollution Index (CEPI)

Methodology and Assessment



Comprehensive Environmental Pollution Index (CEPI)

Methodology and Assessment

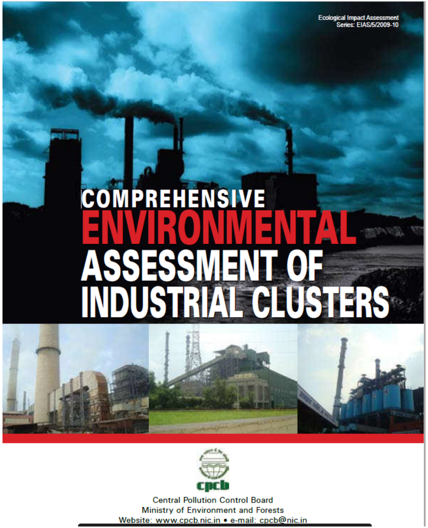
Ambient Air Monitoring Station. Sujana Metals Unit-IV

Surface Water Sampling Point. Isukavagu

Ground Water Sample Point. Bollaram Village

Ground Water Sample Point. Krishnareddypet

Comprehensive Environmental Pollution Index (CEPI)



Comprehensive Environmental Pollution Index (CEPI)

Table 5 CEPIs of various Industrial areas/ clusters for Air Environment

No.	Industrial Cluster/Area	A1	A2	A	B1	B2	B3	B	C1	C2	C3	C	D	AIR CEPI
1	Agra (Uttar Pradesh)	6.00	2.50	15.00	8.00	3.00	3.00	14.00	5.00	3.00	5.00	20.00	10.00	59.00
2	Ahmedabad (Gujarat)	6.00	5.00	30.00	7.75	3.00	3.00	13.75	3.00	3.00	0.00	9.00	10.00	62.75
3	Aligarh (Uttar Pradesh)	6.00	2.50	15.00	8.00	3.00	3.00	14.00	3.00	3.00	5.00	14.00	10.00	53.00
4	Angul Talcher (Orissa)	2.00	5.00	10.00	3.00	3.00	3.00	9.00	5.00	5.00	5.00	30.00	15.00	64.00
5	Ankleshwar (Gujarat)	5.00	5.00	25.00	8.00	6.00	6.00	20.00	3.00	4.00	5.00	17.00	10.00	72.00

Comprehensive Environmental Pollution Index (CEPI)

Table 7 CEPIs of various Industrial areas/ clusters for Land (Soil & Groundwater)

No.	Industrial Cluster/Area	A1	A2	A	B1	B2	B3	B	C1	C2	C3	C	D	LAND CEPI
1	Agra (Uttar Pradesh)	5.50	2.50	13.75	7.00	0.00	0.00	7.00	5.00	4.75	5.00	28.75	10.00	59.50
2	Ahmedabad (Gujarat)	3.00	5.00	15.00	8.00	3.00	3.00	14.00	3.00	3.00	5.00	14.00	15.00	58.00
3	Aligarh (Uttar Pradesh)	2.00	2.50	5.00	8.00	3.00	3.00	14.00	3.00	3.00	5.00	14.00	15.00	48.00

Comprehensive Environmental Pollution Index (CEPI)

Table 6 CEPIs of various Industrial areas/ clusters for Surface Water

No.	Industrial Cluster/Area	A1	A2	A	B1	B2	B3	B	C1	C2	C3	C	D	WATER CEPI
1	Agra (Uttar Pradesh)	5.50	2.50	13.75	7.00	0.00	3.00	10.00	5.00	5.00	5.00	30.00	10.00	63.75
2	Ahmedabad (Gujarat)	3.00	5.00	15.00	8.00	3.00	3.00	14.00	3.00	3.00	5.00	14.00	15.00	58.00
3	Aligarh (Uttar Pradesh)	2.00	2.50	5.00	8.00	3.00	3.00	14.00	3.00	3.00	5.00	14.00	15.00	48.00

Comprehensive Environmental Pollution Index (CEPI)

Table 8 **The CEPI scores for industrial areas/ clusters descending order**

No.	Industrial Cluster/Area	AIR	WATER	LAND	CEPI	
1.	Ankleshwar (Gujarat)	72.00	72.75	75.75	88.50	Ac_Wc_Lc
2.	Vapi (Gujarat)	74.00	74.50	72.00	88.09	Ac_Wc_Lc
3.	Ghaziabad (Uttar Pradesh)	68.50	75.25	71.50	87.37	Ac_Wc_Lc
4.	Chandrapur (Maharashtra)	70.75	67.50	66.50	83.88	Ac_Wc_Lc

Comprehensive Environmental Pollution Index (CEPI)

Compliance

- Clusters with CEPI ≥ 60 subject to central monitoring at the national level, rather than the relatively weak local control, and quarterly emissions audits.
- If CEPI ≥ 70 additionally mandated to submit a remedial action plan for approval detailing the actions and timelines at the cluster and firm levels.
- Failure to comply with the directives of the action plan:
  - → Lose their Environmental Clearance and Consent to Operate permits that allow firms to function within the formal economy.
  - → Consent to Establish permits could not be issued to new operations.

DATA & EMPIRICAL STRATEGY

Datasets

- 2009 policy documents from the CPCB
- Location of industrial clusters in 2009 Construction
- Cluster-level air emissions from satellite readings
  - → Emission Database for Global Atmospheric Research (EDGAR) Construction
  - → Van Donkelaar $PM_{2.5}$
- Prowess and CapEx databases from Centre for Monitoring the Indian Economy (CMIE)
  - → Financial statements
  - → Product-level inputs and outputs
  - → Plant announcements
- Business formation from Ministry of Corporate Affairs (MCA)
- 2001 Population Census

Descriptive Statistics Balance Tables

Empirical Specification

Cluster, firm, and product level specifications

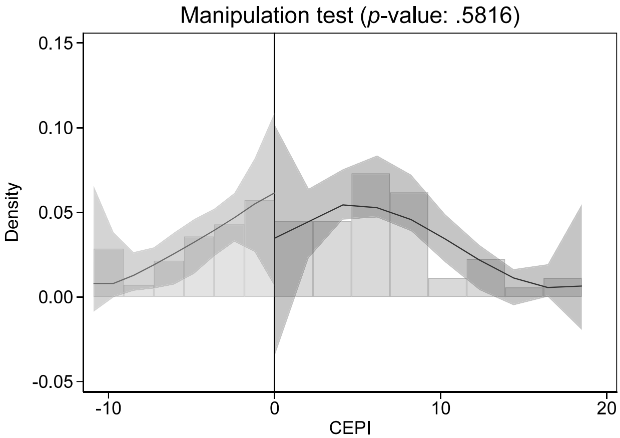
$$Y_{kijcst} = \beta_1 Post_t \times CEPI_c^{[60,70)} + \beta_2 Post_t \times CEPI_c^{[70,100]} + $$
$$+\beta_3 CEPI_c + \beta_4 Post_t + \gamma_i + \kappa_{jst} + \epsilon_{kijcst}$$

- k,i, j, c, s, and t represent a product, firm, industry, city, state, and year, respectively.
- $CEPI_c^{[60,70)}$ is one if the firm's industrial cluster has a **max** CEPI score $\geq$ 60 and below 70, and zero otherwise.
- $CEPI_c^{[70,100]}$ is one if the firm's industrial cluster has a **max** CEPI score $\geq$ 70, and zero otherwise.
- $Post_t$ is one after the regulation was implemented in 2009, and zero otherwise.
- Fixed effects: Firm (γ_i) and State $\times$ industry $\times$ Year (κ_{jst})
- Cluster standard errors at the cluster-level
- Estimate within a bandwidth of 10 CEPI ranking
- β_1: difference in discontinuity effect of crossing the treatment threshold at CEPI = 60

Identification Assumptions

DiD + RD = DiRD

1. No manipulation of the running variable



Identification Assumptions

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2. No geographic clustering

Identification Assumptions

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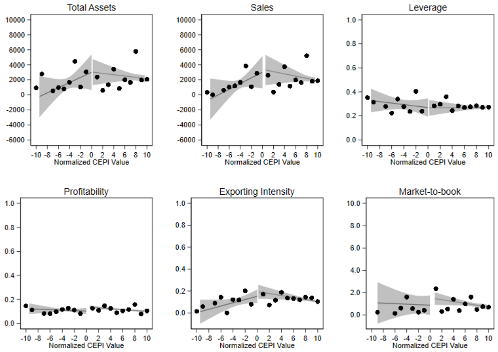
3. No jumps in firm and product characteristics around the threshold



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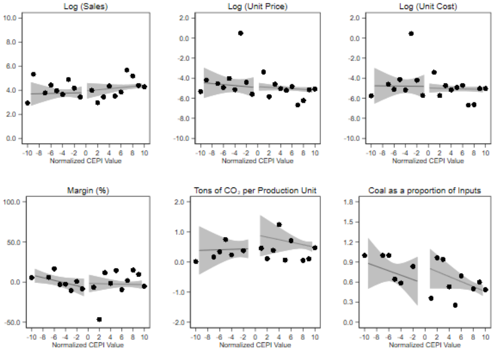

Identification Assumptions

DiD + RD = DiRD

1. No manipulation of the running variable
2. No geographic clustering
3. No jumps in firm and product characteristics around the threshold
4. Parallel trends Figures

RESULTS

Results

- Improved pollution metrics at the cluster and product levels
- Treated firms green production, invest in abatement
- Highest polluting firms drive results
- Firm and regulator actions lower cost, but loss of aggregate dynamism

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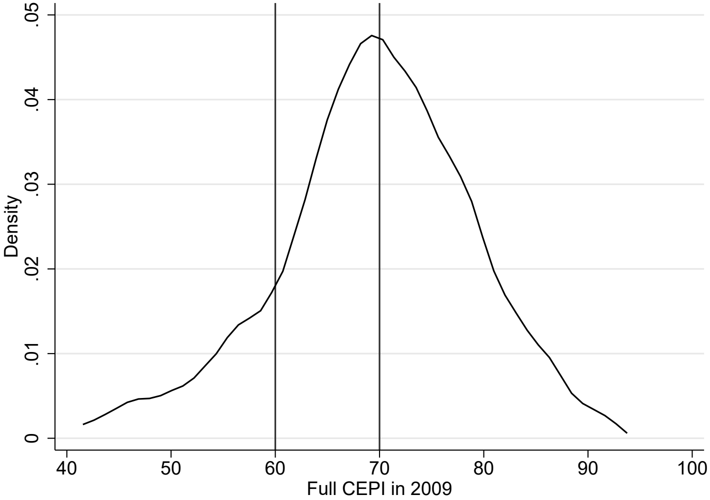
Comprehensive Environmental Pollution Index (CEPI)



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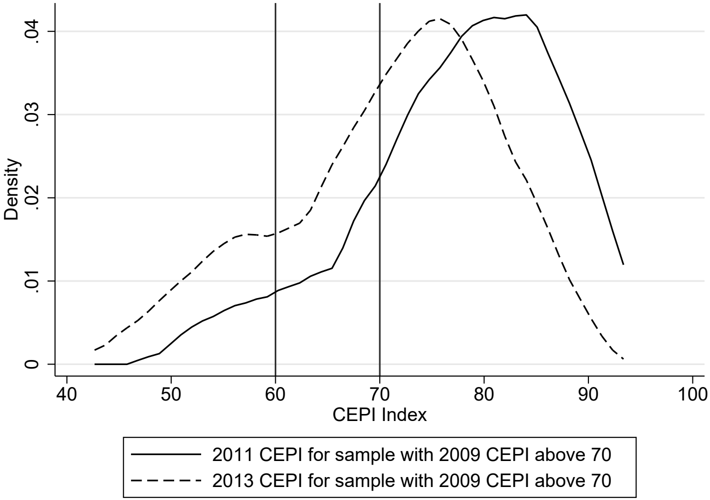
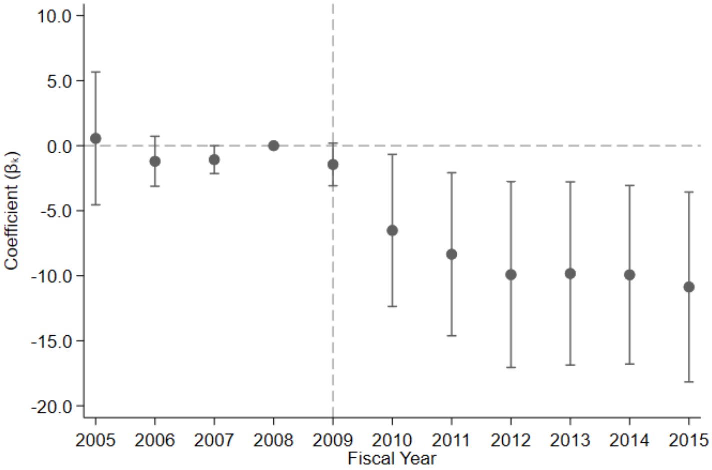


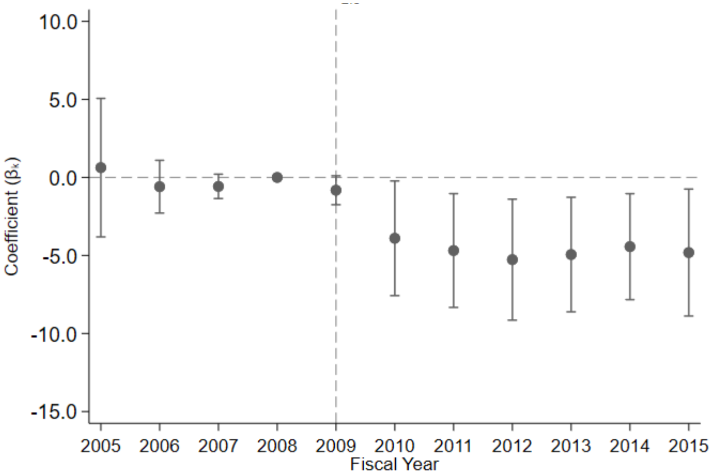
Cluster-Level Satellite Readings: Industrial Emissions, All Pollutants

Units: mg per month



Cluster-Level Satellite Readings: Particulate Matter $< 2.5\mu$

Units: mg per month



Van Donkelaar $PM_{2.5}$

Placebo

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Product Energy Inputs

Firms reduce energy and coal use while electrifying production

Dependent variable	Ln(Value Energy Input)	$\mathbb{1}_{\text{Coal Use}}$	Proportion Purchased Electricity
Post $\times$CEPI$^{[60,70)}$ (β_1)	-1.006***	-0.289*	0.196***
	(0.219)	(0.150)	(0.059)
Post $\times$CEPI$^{[70,100]}$ (β_2)	-0.818**	-0.301***	0.100**
	(0.294)	(0.092)	(0.036)
Ln(Production Quantity)	-0.208	0.033	-0.034
	(0.300)	(0.027)	(0.036)
2008 Dependent Variable Mean (Control)	8.906 M INR	0.17	0.46
R^2	0.795	0.496	0.786
Observations	901	565	901
p-value $[\beta_1 - \beta_2 = 0]$	0.549	0.905	0.124
ATE	-0.773	-0.308	0.151
	[5.465]	[3.350]	[3.159]

Notes. All models include Firm and State $\times$ industry $\times$ year FE.

Firm-level

Product-Level Emissions

Product emissions fall, consistent with cluster level evidence

Dependent variable:	Ln(Product CO_2 Emissions)	Ln(Per Unit CO_2 Emissions)
Post $\times$CEPI$^{[60,70)}$ (β_1)	-1.083***	-0.885***
	(0.283)	(0.306)
Post $\times$CEPI$^{[70,100]}$ (β_2)	-0.944**	-0.687**
	(0.346)	(0.270)
Ln(Production Quantity)	0.801**	
	(0.334)	
2008 Dependent Variable Mean (Control)	162,229.58	2.79
R^2	0.893	0.774
Observations	901	901
p-value $[\beta_1 - \beta_2 = 0]$	0.691	0.579
ATE	-1.414	-0.755
	[5.460]	[3.709]

Notes. All models include Firm and State $\times$ industry $\times$ year FE.

Product Portfolio Weights

Relative shift away from dirtiest products

Dependent variable:	Product with Highest Coal Weight_{2008}	Product with Highest Emissions Weight_{2008}
Post $\times$CEPI$^{[60,70)}$ (β_1)	-0.309**	-0.318**
	(0.123)	(0.118)
Post $\times$CEPI$^{[70,100]}$ (β_2)	-0.139	-0.184*
	(0.114)	(0.101)
2008 Dependent Variable Mean (Control)	0.78	0.65
R^2	0.775	0.758
Observations	705	705
p-value $[\beta_1 - \beta_2 = 0]$	0.123	0.215
ATE	-0.181	-0.218
	[1.438]	[1.981]

Notes. All models include Firm and State $\times$ industry $\times$ year FE.

Abatement Expenditures from Financial Statements

Abatement expenditures increase on extensive and intensive margins

Dependent variable:	$\mathbb{1}_{\text{Abatement}}$	Abatement/Assets
Post $\times$CEPI$^{[60,70)}$ (β_1)	0.048	0.039*
	(0.031)	(0.020)
Post $\times$CEPI$^{[70,100]}$ (β_2)	0.077**	0.038**
	(0.029)	(0.016)
2008 Dependent Variable Mean (Control)	0.06	0.01
R^2	0.725	0.753
Observations	10,752	10,752
p-value $[\beta_1 - \beta_2 = 0]$	0.029	0.933
ATE	0.072	0.038
	[2.419]	[2.385]

Notes. All models include Firm and State $\times$ industry $\times$ year FE.

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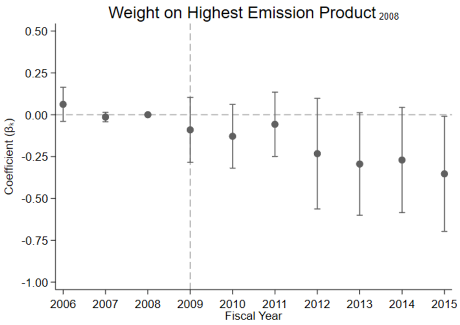
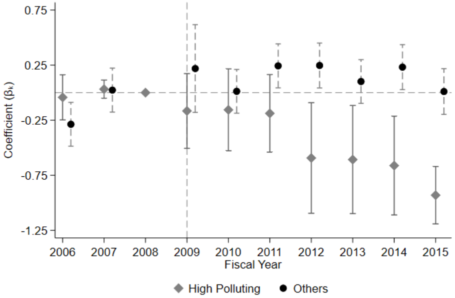
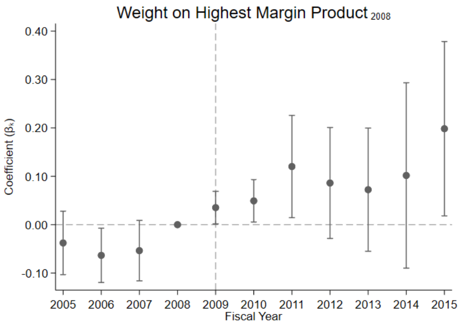
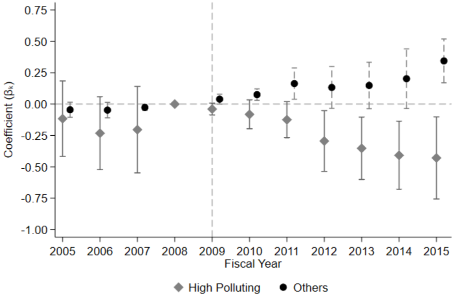
Changes to Firm Emissions: Portfolio Shifts





Changes to Firm Profitability: Portfolio Shifts





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Action Plans and Annual Reports

Haldia Planning Area, West Bengal: 2009 CEPI: 75.43
2013 CEPI: 61.58

Fig. -1: Boundary of critically polluted area in Haldia

Action Plans and Annual Reports

12. Summary of proposed action points

12.1 Short Term Action Points (up to 1 year, including continuous Activities)

Sr No	Action Points (including source & mitigation measures)	Responsible Stake Holders	Time limit	Cost	Remarks
WATER					
1. Standard flow meter at final outlet of ETP					
1	Identification of units having effluent quantity more than 25 m^3/day.	GPCB, Concerned industries, CIA	Completed 30.06.2010	-----	To control overflowing of CIA pipeline in future, it is necessary to control the discharge of excessive quantity of wastewater from the industrial units. **Identification completed**
	Industrial Association will issue the circular to their member to provide the Standard flow meter.	Concerned industries, CIA	31.12.2010	3.30 lacs	It is necessary to have metering system consisting of Standard Flow Meter (MFM) at the final outlet for industries having discharge more than 25 m3/day. **Out of identified units, four industries have already provided the flow meter and rest has procured for installation during connection to the conveyance system.**

Action Plans and Annual Reports

Sl. No.	Action Points (including source & mitigation measures)	Responsible Stake Holders	Time Limit	Cost	Remarks
1	Installation of CETP	Industry Association & Industry, WBPCB, MOEF as per CETP cost sharing principle of MOEF coordinated by SPCB	By June 2012	1.5 Crore	Necessary funding may be granted through WBPCB
2	Installation of AAAQM	Industry Association & Industry	By June 2012	02 Crore	Necessary funding may be granted through WBPCB
3	Development of proper drainage facility	Industry Association & Industry	By June 2012	02 Crore	Necessary funding may be granted through WBPCB. The possibility of accessing Infrastructural Funding Assistance from GOI will be explored.

Action Plans and Annual Reports

Name	Technology adopted during last one year			Time frame
	Air	Water	Land	
5. Tata Chemicals Ltd.	1. Dry Fog system and water sprinkling System. (Coal Handling plant, coke Handling plant, Material Handling System, Wagon Trippler) 2. Fully covered Wagon Tippler and conveyor belts . (Coal unloading station). 3. Green Belt Development. Within factory premises. 4. Power plant with 16 nos of WHRBs. Along with the process.	1. Boiler blow down water is mixed with quenching pond water and is used for Coke quenching purpose in 2 rows 2. Cooling Tower discharge water is mixed with quenching pond water and is used for Coke quenching purpose in other 2 rows 3.Quenching	1.Coke Swamp breeze is the only solid waste (non – hazardous in nature) generated from the process. The average generation of swamp breeze is approx 1000 tons per month which is being sold to third party completely 2. Total 15000 (approx) numbers of trees planted till date, nearly 2000 saplings have been planted	Already impleme nted

Action Plans and Annual Reports

JK Lakshmi Cement Limited Annual Report

> During the year, the Company further improved its operating efficiencies. There was reduction in consumption of both power and fuel per unit of production. In addition, the Company improved usage of alternate fuel of bio-mass from 2% to 6%. These improvements have enabled the Company to also reduce the carbon footprint.

Firm Productivity and Profitability

- Firms increase productivity and profitability, shifting towards high-margin products >
- Highly polluting industries bear higher costs >...
  - → ...but achieve significant emission reductions >
  - → Regulator, local government share costs with industry groups >
- Non-highly polluting industries increase product margins >

Aggregate Effect and Other Explanations

- Product variety decreases >

- Business dynamism within cluster decreases driven by lower firm entry
  → All firms (include small firms) >
  → Large firms (Prowess) >

- No evidence firms shift production location
  → No effect on mergers and acquisitions >
  → No affect on new plant announcements >

Open the "Brown Box:" Production Responses to Emissions Regulation

We find:

- Firms lower emissions by (1) shifting away from high-emission energy sources, (2) electrifying production, and (3) investing in abatement
- Regulated clusters exhibit lower firm entry and product variety
- More highly regulated firms reduce emissions the most and bear the brunt of costs
- In aggregate, productivity and profitability maintained

Implications:

- Important for environmental regulation design when enforcement and monitoring are weak (**Greenstone and Jack (2015)**, **Duflo et al. (2018)**)
- Can cap geographically-tied emissions, but exacts economic cost
- Design of risk and cost-sharing between industry and government
- Need for coordinating decarbonization policies: industrial and electricity generation

Thank You!

Cluster-Level Satellite Readings: Van Donkelaar $PM_{2.5}$ Measure

Dependent variable:	Fine $PM_{2.5}$ (μ g/m^3)	
Radii of circle:	5 kilometers	500 meters
Post $\times$CEPI$^{[70,100]}$ (β_1)	-2.311***	-1.893**
	(0.775)	(0.743)
Post $\times$CEPI$^{[60,70)}$ (β_2)	-1.018	-0.560
	(0.756)	(0.673)
2008 Dependent Variable Mean (Control)	84.0	84.0
R^2	0.963	0.959
Observations	17,952	18,216

Notes. All models estimated within bandwidth of 10 CEPI; include Cluster & State $\times$ year-month FE.

- Reduction in $PM_2.5$ emissions of 4% relative to the pre-regulation control mean.

Return

Cluster-Level Satellite Readings: Energy Sector Placebo

Return

No effect on emissions of un-treated sector

Dependent variable:	Pollution Measurement			
Pollutant(s):	All	$PM_{2.5}$	PM_{10}	NO_x
Post $\times$CEPI$^{[60,70)}$ (β_1)	-0.229	-0.112	-0.170	-0.405
	(0.715)	(0.274)	(0.542)	(1.415)
Post $\times$CEPI$^{[70,100]}$ (β_1)	-0.169	-0.181	-0.184	-0.143
	(0.755)	(0.304)	(0.549)	(1.520)
2008 Dependent Variable Mean (Control)	8.18	1.78	3.34	19.43
R^2	0.756	0.795	0.823	0.734
Observations	29,808	9,936	9,936	9,936
p-value $[\beta_1 - \beta_2 = 0]$	0.915	0.765	0.975	0.792
ATE	-0.186	-0.161	-0.180	-0.217
	[0.266]	[0.579]	[0.357]	[0.153]

Notes. All models estimated within bandwidth of 10 CEPI; include Firm and State $\times$ industry $\times$ year FE.

Firm-level energy input

Dependent variable:	Ln(Value Firm Energy Input)	
Post $\times$CEPI$^{[60,70)}$ (β_1)	-0.667***	-0.821***
	(0.138)	(0.189)
Post $\times$CEPI$^{[70,100]}$ (β_2)	0.031	-0.018
	(0.095)	(0.190)
Post $\times$CEPI$^{[70,100]}$ $\times$ High-Polluting (β_4)		0.062
		(0.280)
Post $\times$CEPI$^{[60,70)}$ $\times$ High-Polluting (β_3)		0.392*
		(0.223)
2008 Dependent Variable Mean (Control)	219.92	0.214
Adjusted-R^2	0.959	0.959
Observations	358	358
p-value $[\beta_1 - \beta_2 = 0]$	0.003	
ATE	-0.119	
	1.266	

Notes. All models estimated within bandwidth of 10 CEPI; include Firm and State $\times$ industry $\times$ year FE.

Return

Lower Product Variety

Return

Adjust product portfolio to lower product variety

Dependent variable:	Ln(Product-level Production	Ln(No. of Products)	$\mathbb{1}$ Add Product	$\mathbb{1}$ Remove Product
Post $\times$CEPI$^{[60,70)}$ (β_1)	-0.110	0.013	-0.117***	0.003
	(0.182)	(0.078)	(0.041)	(0.036)
Post $\times$CEPI$^{[70,100]}$ (β_2)	0.030	0.007	-0.057*	0.023
	(0.130)	(0.072)	(0.034)	(0.030)
2008 Dependent Variable Mean (Control)	29,784	2.71	0.27	0.17
R^2	0.582	0.746	0.263	0.242
Observations	15,521	10,752	10,752	10,752
p-value $[\beta_1 - \beta_2 = 0]$	0.429	0.904	0.094	0.314
ATE	0.007	0.008	-0.068	0.019
	[0.063]	[0.118]	[2.138]	[0.621]

Notes. All models estimated within bandwidth of 10 CEPI; include Firm and State $\times$ industry $\times$ year FE.

Cluster business dynamism decreases from lower firm entry

Return

Full firm registry

Dependent variable:	$\mathbb{1}_{\text{New Firm}}$	Log(No. of firms)	$asinh$(No. of firms)	No. of firms (Poisson)
Post $\times$CEPI$^{[60,70)}$ (β_1)	-0.009	-0.011	-0.014	-0.105
	(0.011)	(0.010)	(0.013)	(0.138)
Post $\times$CEPI$^{[70,100]}$ (β_1)	-0.018*	-0.016*	-0.020*	-0.185*
	(0.010)	(0.009)	(0.012)	(0.104)
2008 Dependent Variable Mean (Control)	0.08	0.20	0.20	0.20
R^2	0.449	0.570	0.570	
Observations	33,534	33,534	33,534	19,958
p-value $[\beta_1 - \beta_2 = 0]$	0.154	0.402	0.373	0.735
ATE	-0.013	-0.010	-0.013	-0.169
	[1.360]	[1.206]	[1.189]	[1.582]

Notes. All models estimated within bandwidth of 10 CEPI; include Firm and State $\times$ industry $\times$ year FE.

Firm Entry: Prowess (Large) Firms

Dependent variable:	$\mathbb{1}_{\text{New Firm}}$	Log(No. of firms)	$asinh$(No. of firms)	No. of firms (Poisson)
	(1)	(2)	(3)	(4)
Post $\times$CEPI$^{[60,70)}$ (β_1)	-0.003	0.001	0.001	-0.289
	(0.017)	(0.016)	(0.021)	(0.440)
Post $\times$CEPI$^{[70,100]}$ (β_1)	-0.041*	-0.035*	-0.045*	-0.795**
	(0.021)	(0.018)	(0.023)	(0.370)
2008 Dependent Variable Mean (Control)	0.01	0.01	0.01	0.01
Adjusted-R^2	0.172	0.212	0.213	
Observations	4,416	4,416	4,416	678
p-value $[\beta_1 - \beta_2 = 0]$	0.018	0.074	0.076	0.103
ATE				
tvalue				

Notes. All models estimated within bandwidth of 10 CEPI; include Firm and State $\times$ industry $\times$ year FE.

Return

No evidence firms shift production location Return

No effect on mergers and acquisitions

Dependent variable:	$\mathbb{1}_{\text{Target}}$	$\mathbb{1}_{\text{Acquired}}$
Post $\times$CEPI$^{[60,70)}$ (β_1)	0.018	-0.000
	(0.012)	(0.008)
Post $\times$CEPI$^{[70,100]}$ (β_1)	0.009	0.005
	(0.009)	(0.007)
2008 Dependent Variable Mean (Control)	0.00	0.00
Adjusted-R^2	0.193	0.148
Observations	10,752	10,752
p-value $[\beta_1 - \beta_2 = 0]$	0.345	0.430
ATE	0.007	0.003
	[0.740]	[0.534]

Notes. All models estimated within bandwidth of 10 CEPI; include Firm and State $\times$ industry $\times$ year FE.

No evidence firms shift production location Return

No affect on new plant announcement or plant abandonment

Dependent variable:	$\mathbb{1}_{\text{New Plant}}$	$\mathbb{1}_{\text{Abandon Plant}}$
Post $\times$CEPI$^{[60,70)}$ (β_1)	0.008	0.003
	(0.013)	(0.011)
Post $\times$CEPI$^{[70,100]}$ (β_1)	-0.010	-0.004
	(0.011)	(0.010)
2008 Dependent Variable Mean (Control)	0.00	0.00
R^2	0.350	0.284
Observations	10,752	10,752
p-value $[\beta_1 - \beta_2 = 0]$	0.099	0.100
ATE	-0.007	-0.002
	[0.590]	[0.238]

Notes. All models estimated within bandwidth of 10 CEPI; include Firm and State $\times$ industry $\times$ year FE.

Productivity and Profitability

Return

Dependent variable:	Ln(TFP)	EBITDA/ Sales	Raw Material Expense
Post $\times$CEPI$^{[60,70)}$ (β_1)	0.100	0.004	-0.033
	(0.075)	(0.015)	(0.030)
Post $\times$CEPI$^{[70,100]}$ (β_2)	0.127***	0.008	-0.034
	(0.039)	(0.014)	(0.027)
2008 Dependent Variable Mean (Control)	2.77	0.10	0.56
R^2	0.851	0.638	0.641
Observations	10,752	10,752	10,752
p-value $[\beta_1 - \beta_2 = 0]$	0.695	0.556	0.952
ATE	0.122	0.007	-0.034
	[3.238]	[0.496]	[1.326]

Notes. All models estimated within bandwidth of 10 CEPI; include Firm and State $\times$ industry $\times$ year FE.

Quantity Productivity

Productivity and Profitability

Return

Firms in non-HPI drive productivity gains

Dependent variable:	Ln(TFP)	EBITDA/ Sales	Raw Material Expense
Post $\times$CEPI$^{[60,70)}$ (β_1)	0.131*	0.008	-0.061**
	(0.074)	(0.015)	(0.030)
Post $\times$CEPI$^{[70,100]}$ (β_2)	0.146***	0.009	-0.039
	(0.043)	(0.015)	(0.027)
Post $\times$CEPI$^{[60,70)}$ $\times$ High-Polluting (β_3)	-0.114	-0.016	0.095***
	(0.161)	(0.011)	(0.032)
Post $\times$CEPI$^{[70,100]}$ $\times$ High-Polluting (β_4)	-0.076	-0.004	0.017
	(0.054)	(0.007)	(0.013)

Notes. All models estimated within bandwidth of 10 CEPI; include Firm and State $\times$ industry $\times$ year FE.

Quantity Productivity

Return

Dependent variable:	Log(Quantity-based Productivity)	
Post $\times$CEPI$^{[70,100]}$ (β_1)	-0.174	-0.118
	(0.153)	(0.164)
Post $\times$CEPI$^{[60,70)}$ (β_2)	-0.287	-0.190
	(0.176)	(0.302)
Post $\times$CEPI$^{[70,100]}$ $\times$ High-Polluting (β_3)		-0.184
		(0.127)
Post $\times$CEPI$^{[60,70)}$ $\times$ High-Polluting (β_4)		-0.189
		(0.376)
2008 Dependent Variable Mean (Control)	8.6	8.6
Firm FE	Yes	Yes
State $\times$ industry $\times$ year FE	Yes	Yes
Bandwidth	Yes	Yes
R^2	0.824	0.825
Observations	1,898	1,898

Competitive Effect? Return

No change in pricing; margins likely driven by portfolio shift

Dependent variable:	Highest Margin Product Weight$_{2008}$	Product Margins	Ln(Unit Price)	Ln(Unit Cost)
Post $\times$CEPI$^{[60,70)}$ (β_1)	0.120**	0.037	-0.059	-0.016
	(0.050)	(0.081)	(0.225)	(0.194)
Post $\times$CEPI$^{[70,100]}$ (β_2)	0.124***	0.147***	-0.129	-0.221
	(0.046)	(0.054)	(0.220)	(0.197)
2008 Dependent Variable Mean (Control)	0.72	0.00	0.72	0.89
R^2	0.880	0.722	0.592	0.599
Observations	15,984	15,225	15,984	15,225
p-value $[\beta_1 - \beta_2 = 0]$	0.865	0.140	0.439	0.056
ATE	0.124	0.126	-0.116	-0.183
	[2.731]	[2.179]	[0.538]	[0.966]

Notes. All models estimated within bandwidth of 10 CEPI; include Firm and State $\times$ industry $\times$ year FE.

Competitive Effect? Return

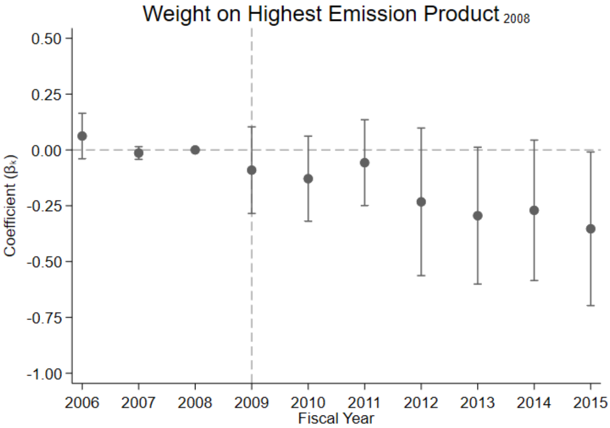
HPI de-emphasize highest-margin product because it is high emission?

Dependent variable:	Highest Margin Product Weight$_{2008}$	Product Margins	Ln(Unit Price)	Ln(Unit Cost)
Post $\times$CEPI$^{[60,70)}$ (β_1)	0.166***	0.018	-0.055	0.024
	(0.053)	(0.096)	(0.218)	(0.193)
Post $\times$CEPI$^{[70,100]}$ (β_2)	0.129***	0.157***	-0.160	-0.255
	(0.047)	(0.052)	(0.220)	(0.200)
Post $\times$CEPI$^{[60,70)}$ $\times$ High-Polluting (β_3)	-0.122**	0.043	0.003	-0.084
	(0.058)	(0.078)	(0.185)	(0.207)
Post $\times$CEPI$^{[70,100]}$ $\times$ High-Polluting (β_4)	-0.015	-0.042	0.112	0.137
	(0.017)	(0.032)	(0.082)	(0.123)

Notes. All models estimated within bandwidth of 10 CEPI; include Firm and State $\times$ industry $\times$ year FE.

Product Portfolio: Weight Highest Emission Product Return

Production changes driven by firms in HPI



Product Portfolio: Weight Highest Emission Product

Return

Production changes driven by firms in HPI