Opening the Brown Box: Production Responses to Environmental Regulation[†]

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Abstract

We study manufacturers' production responses to an emissions capping regulation. Firms lower emissions by improving energy efficiency, substituting to cleaner fuels and shifting from producing electricity to purchasing it from the grid. They move away from coal-intensive products and adopt abatement technologies. However, in the aggregate, we document lower product variety and an altered firm-size distribution driven by reduced business formation. A back-of-the-envelope analysis indicates that the policy is cost-effective due to substantial environmental gains. Overall, this paper highlights how environmental regulation shapes industrial production and the resulting trade-offs between pollution reduction and long-term economic growth.

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Policymakers increasingly rely on targeted, place-based regulations to reduce emissions (IPCC, 2023; World Economic Forum, 2023). At the same time, they care *how* firms achieve reductions, preferring that they improve energy efficiency, invest in abatement, and modernize production (Stern and Jotzo, 2010). However, a key constraint in designing effective regulation is limited evidence on firms' production responses. Absent evidence, it is difficult to discern the true economic costs of regulation and whether observed outcomes reflect costly distortions or efficient responses (Gechter and Kala (2025); Greenstone (2002); Greenstone and Hanna (2014); He et al. (2020)).

On the one hand, firms may relocate or expand their operations to regions with less stringent oversight. Indeed, research documents that localized policies lead to a shift in emissions across geographies, within firms, or through the supply chain (Bartram et al., 2022; Ben-David et al., 2021; Dai et al., 2021; Duchin et al., 2022; Schiller, 2018). On the other hand, firms may face optimization frictions, including financial constraints and information asymmetries, that hinder the adoption of cleaner technologies (Bustamante and Zucchi, 2024; Lanteri and Rampini, 2025). Distinguishing between these two responses is central to designing effective environmental policy, as policymakers face enforcement and informational constraints that limit their ability to effectively target reductions (Duflo, Greenstone, Pande, and Ryan, 2013, 2018).

In this paper, we fill this gap by studying *within-firm* production responses to environmental regulation. We combine detailed data on firm production and abatement expenditures with variation from an environmental regulation in India. Using hand-collected regulatory data and satellite pollution measurements, we show that the regulation significantly reduced emissions. Exploiting detailed product-level data, we find that firms lower their energy expenditures without reducing output, which implies improved energy efficiency. Firms shift from producing electricity in-house to procuring it. At the product portfolio level, they move away from producing their highest-emission and most coal-intensive products. At the same time, they substantially increase pollution abatement spending, both at the extensive and intensive margins. Moreover, we find that subsidies and cost-sharing facilitate compliance through adoption of cleaner technologies among financially-constrained firms. Notably, we do not find that firms shift economic activity elsewhere. However, at the aggregate level, we document a decline in business dynamism, evidenced by lower product variety and reduced firm entry.

We study an emissions-capping regulation targeting industrial clusters, co-located dynamic concentrations of related businesses, imposed by the national regulator, the Central Pollution Control Board (CPCB). In 2009, the CPCB introduced the Comprehensive Environmental Pollution Index (CEPI) to quantify pollution levels of industrial clusters and their impact on local populations. Clusters with CEPI values exceeding *pre-defined* thresholds reflecting the severity of environmental degradation faced mandatory emissions reductions, which included enhanced monitoring and remedial action plans. We exploit the resulting discontinuities in enforcement intensity, both within and across industrial clusters, around the implementation of the regulation. Combined with detailed firm and product data, this allows us to identify *within-firm* changes in production decisions and to study the costs and benefits of the regulation.

Our analysis proceeds in four parts: (1) it assesses changes in cluster-level emissions, (2) examines energy and fuel use, (3) analyzes changes in product portfolios and abatement investment, and (4) evaluates broader economic costs, including effects on product variety and firm entry. In the first part of the paper, we show that the regulation substantially reduced emissions in the targeted industrial clusters. Using hand-collected data from follow-up monitoring studies by the CPCB, we find that clusters facing the highest enforcement intensity, significantly decreased their emissions. We corroborate these findings with satellite measurements of emissions, which confirm a significant and persistent decline. In placebo tests, we show that there is no commensurate change in agricultural emissions, that are unrelated to the regulation, thus mitigating concerns about omitted variables.

The average reduction in cluster emissions masks significant heterogeneity in compliance across clusters. To investigate this variation, we hand-collected follow-up assessments and related cluster-level outcomes to characteristics of state pollution regulators. The regulation subjected enforcement decisions of local authorities to national regulatory approval, introduced continuous emissions monitoring at fixed points in each cluster, and implemented random third-party audits throughout the year. In the most polluting clusters, the policy also required the development of action plans, mandating firm abatement measures on court-enforceable timelines. We find that, in these clusters, emission reductions are larger in areas with proxies that positively correlate with higher regulator quality and enforcement capacity, a greater proportion of small firms, and with subsidies that supported abatement investments. These findings underscore the significance

of public-private cost sharing in reducing emissions and complement research highlighting the role of regulatory institutions in achieving this in contexts characterized by low state capacity and high information asymmetries (Duflo et al., 2013; Pande and Datla, 2016).

Second, we study the *within-firm* drivers of the aggregate reduction in emissions. We leverage detailed product information on inputs and outputs from private and public manufacturers—uniquely available in India due to disclosure requirements (Bau and Matray, 2023; De Loecker et al., 2016). Firms respond to the regulation by improving their energy efficiency—decreasing their energy expenditures without significantly changing their product output. A meaningful shift in fuel use accompanies these gains, with treated firms reducing coal inputs by 29% relative to control clusters. We also find that firms shift from producing to purchasing electricity—they increase the proportion of energy they source from the grid by 19.6 percentage points. Nevertheless, the scale of this shift exposes firms to risk, given the unreliability of the power supply in India (Burgess et al., 2020).[1] As firms transition from self-generation using diesel generators to relying on the grid, they forgo the insurance value that generators offer against power outages.

Third, we find that treated firms shift their product portfolios away from their highest-emission, coal-intensive products—those typically associated with greater pollution. Moreover, these firms increase their abatement expenditures along both the extensive and intensive margins: treated firms are twice as likely to make any abatement expenditure, and they increase abatement spending by 3.9 percentage points, on average. These responses are stronger in clusters subject to abatement action plans. Smaller firms typically face tighter financial constraints and thus may be more sensitive to upfront abatement costs. Consistent with this, we find that smaller firms' abatement responses are more pronounced, and combined with the results on cluster-level heterogeneity, highlight the importance of subsidies and cost-sharing in facilitating compliance where state capacity and information are limited. At the same time, we do not see any change in capital stock, wage bill, and raw material expenditure, suggesting that firms were able to improve efficiency without scaling up inputs.

Fourth, we examine the broader costs of these regulations. We find no significant impact on firm production. However, treated firms are 12 percentage points less likely to introduce a

[1]Research, in the context of India and other economies, has shown that unreliable power supply reduces firm productivity (Allcott et al. (2016); Cole et al. (2018); Fried and Lagakos (2023)), raises production costs (Steinbuks and Foster (2010); Fisher-Vanden et al. (2015)), and decreases profitability (Szakonyi and Urpelainen (2013)).

new product in the five years following the regulation, indicating lower product variety. At the cluster level, we find a decrease in entry by firms operating in *all industries*—not just manufacturing—and across the firm size distribution. Specifically, new firm registrations drop by 1.4 percentage points relative to a baseline rate of 7%. Despite these costs, our back-of-the-envelope analysis suggests the regulation is cost-effective, with annual mortality benefits of approximately $3.47 billion exceeding total estimated annual costs of $2.28 billion. Therefore, even when accounting for tangible costs to firms and lower business dynamism, the gains from reduced pollution and lower mortality outstrip the costs.

We also test alternative explanations for the observed emission reductions. A key concern is that firms may have moved production outside regulated clusters or shifted their emissions by expanding capacity elsewhere. Note that we observe product-level production at the firms and not only within treated clusters, so within-firm relocation across clusters is inherently captured in our analyses. Nonetheless, we present four additional pieces of evidence to further rule out concerns about production shifting. First, we estimate significant improvements in energy efficiency but no changes in raw material expenses, wage bills, and capital investments, suggesting that firms did not shift their product markets. Second, we do not find a change in the probability of mergers or acquisitions, even in high-enforcement clusters. Third, we find no treatment effect on the likelihood of announcing a new plant or abandoning the expansion of an existing one. Finally, we estimate heterogeneity by firm size, a proxy for the scope for production shifting, again finding no change in production quantities. Taken together, these patterns are inconsistent with emissions leakage. Instead, we show that firms responded to the regulation with production changes and the adoption of cleaner technology.

By documenting within-firm production decisions, this paper "opens the brown box" of how firms respond to environmental regulation. Measuring granular production responses is critical because these responses highlight the specific margins of adjustments that feed into the the broader economic costs of compliance. Understanding whether firms reduce emissions through operational efficiency, input substitution, or portfolio re-balancing is important for interpreting whether observed outcomes reflect costly distortions or efficient responses. Our findings highlights that environmental regulation shapes industrial production and have broad implications for trade-offs between pollution reduction and long-term economic growth.

While we focus on India, due to the availability of granular data and a quasi-natural experimental setting, our findings have implications for other regions considering emissions reduction policies in industrial clusters. For example, the World Economic Forum recently launched a global initiative that aims to reduce heavy industry asset emissions in regional industrial zones (World Economic Forum, 2023).[2] Notably, these clusters account for a significant fraction of global CO_2 emissions. Our study highlights that, although emission caps on industrial clusters can contribute significantly to net-zero goals, these policies also impose economic trade-offs, potentially reducing competitiveness by weakening the agglomeration benefits clusters provide.

More broadly, our study shows that place-based regulation that combines targeted monitoring with subsidies is likely to help reduce emissions in large, industrializing economies trying to balance rapid growth with decarbonization.[3] A key takeaway for policymakers is the central role of financial considerations and public-private cost sharing; compliance was strongest where enforcement was credible and paired with financial support for abatement investments, particularly for small and medium-sized firms. Furthermore, our results on the observed shift toward grid electricity further suggests that policymakers must coordinate sectoral policies both on the supply and demand sides to ensure a smooth transition.

Our paper contributes to three strands of the literature. First, it contributes to the literature on environmental regulation by documenting how firms alter their input and output choices at the product level in response to emissions regulation. Studies have examined the emissions and firm impacts of environmental regulations (Berman and Bui (2001); Greenstone et al. (2012); Harrison et al. (2019); He et al. (2020); Kala and Gechter (2023)).[4] However, data limitations have constrained efforts to open the "brown box" of firm behavior—particularly the production changes they make and the associated economic trade-offs. Our novel setting and data allow us to directly observe how firms reduce emissions—whether by shifting production, cutting output, switching inputs, or adopting cleaner production processes. Distinguishing among these responses matters because each has different implications for both the regulatory effectiveness

[2]Nine leading industrial clusters in China, Indonesia, Japan, Spain, and the United States have joined the World Economic Forum initiative, "Transitioning Industrial Clusters towards Net Zero," to help industries reduce emissions.

[3]As of 2025, most such economies regulate using place-based emissions policies rather than carbon pricing (World Bank, 2025).

[4]Another strand of the literature examines the role of carbon taxes (Metcalf (2021); Brown et al. (2022); Martinsson et al. (2024)) and carbon pricing (Fowlie et al. (2012); Klemetsen et al. (2020); Colmer et al. (2024)), finding mixed evidence on their effectiveness.

and the economic cost of pollution regulation. Moreover, our results highlight the importance of accurately identifying firm-level parameters essential for integrated assessment models that aim to trace the macroeconomic impacts of decarbonization. For example, the optimal energy tax depends on the degree of substitution between fuel sources (Golosov et al., 2014), and the long-run sustainability of economic growth depends on the substitutability of dirty and clean inputs (Acemoglu et al., 2012).

Second, we show that alleviating financial constraints helps encourage the adoption of cleaner technologies. In doing so, we contribute to the growing literature on the importance of financial constraints in affecting environmental outcomes. Empirical work has focused on how deterioration in financial conditions affects incentives to shift pollution and risk-taking (Bartram et al., 2022; Duchin et al., 2010; Xu and Kim, 2022). Recent theoretical papers highlight the importance of financial constraints in facilitating the adoption of cleaner technologies (Albuquerque et al., 2025; Bellon and Boualam, 2024; Bustamante and Zucchi, 2024, 2025; Lanteri and Rampini, 2025). We provide novel evidence supporting these models by showing that, when firms overcome financing frictions through subsidies and public-private cost sharing, they respond to regulation by investing in cleaner technologies. Consequently, we show that financing capacity drives the extensive and intensive margin of abatement investment, determining whether environmental regulation leads to an efficient green transition instead of a reallocation of pollution.

Third, our study contributes to the burgeoning literature on the environmental impact of firms.[5] Research has highlighted the importance of the nature of ownership (Dimson et al. (2015); Krueger et al. (2020); Naaraayanan et al. (2021); Dimson et al. (2021); Azar et al. (2021); Atta-Darkua et al. (2023); Ilhan et al. (2023); Berg et al. (2023)), disclosures (Jouvenot and Krueger (2019); Tomar (2023); Bonetti et al. (2023)), financial institutions (Kacperczyk and Peydró (2022); De Haas (2023); De Haas and Popov (2023); Ivanov et al. (2024)), and self-commitments (Dahlmann et al. (2019); Freiberg et al. (2021); Comello et al. (2021); Duchin et al. (2022); Bolton and Kacperczyk (2023)). Our contribution lies in documenting how production responses to environmental regulation shape the environmental profile of firms while highlighting firms' trade-offs when balancing emissions reduction with economic impacts.

[5] In contrast to a literature analyzing the implications of investors' green preferences on asset prices (e.g., Heinkel et al. (2001); Chowdhry et al. (2018); Pástor et al. (2021); Pedersen et al. (2021); Berk and Van Binsbergen (2021); Bolton and Kacperczyk (2021); Broccardo et al. (2022); Zerbib (2022); Oehmke and Opp (2023); and De Angelis et al. (2023).

1 Institutional Background

This paper studies an environmental regulation in India targeting pollution from industrial clusters——co-located concentrations of related businesses. Clusters are often associated with positive productivity and innovation spillovers and promote economic growth. At the same time, they generate significant pollution, which is especially concerning near densely populated areas.[6]

Recognizing this trade-off, the Central Pollution Control Board (CPCB) launched a policy in 2009 to prioritize pollution abatement in the most polluted areas. The CPCB in consultation with the Ministry of Environment, Forest and Climate Change (MoEF&CC), developed the Comprehensive Environmental Pollution Index (CEPI), which identified 88 prominent industrial clusters causing significant pollution near dense urban areas.

Given the regulators' concern for pollution caused by the clusters, they set out to develop a monitoring tool. To do this, the CPCB developed an index, which takes a value between 0 and 100, to characterize the environmental quality at a given location. To arrive at the index, they conducted a comprehensive data-gathering effort in these clusters through recognized environmental laboratories. The CEPI combined proxies for (i) the amount and toxicity of pollutants, (ii) the potential impact of that pollution on humans and ecosystems, and (iii) an assessment of the quality of actions already taken by cluster firms to reduce emissions. Figure 1 describes the construction of the CEPI. See Central Pollution Control Board of India (2009) for a discussion of the components and construction of the CEPI.

[PLACE FIGURE 1 HERE.]

The regulators computed index value in 2009 for each cluster and used it to enforce improvements in environmental quality in these clusters based on whether the values exceeded pre-defined thresholds. In our empirical setting, we exploit the resulting discontinuities in enforcement intensity, both within and across industrial clusters. Specifically, the CPCB classified

[6]Nearly all of India's 1.4 billion people are exposed to air pollution levels exceeding World Health Organization (WHO) standards for particulate matter, often by an order of magnitude (Greenstone et al., 2025). Air pollution has been shown to shorten life expectancy and impair human capital formation during childhood(Ebenstein, Fan, Greenstone, He, and Zhou, 2017; Isen, Rossin-Slater, and Walker, 2017). Estimates suggest that bringing pollution levels across India into compliance with WHO standards would raise average life expectancy by approximately five years (Greenstone and Hanna, 2014; Greenstone and Hasenkopf, 2023).

those clusters with a CEPI at or above 60 and below 70 as "Severely Polluted Areas" (henceforth, $CEPI^{[60,70)}$). These clusters faced central monitoring, which entailed the installation of online continuous emission/effluent monitoring systems combined with in-person quarterly audits.

Further, the regulators classified industrial clusters with a CEPI value of at least 70 as "Critically Polluted Areas" (henceforth, $CEPI^{[70,100]}$). Firms within these clusters faced the same monitoring treatment as $CEPI^{[60,70)}$ clusters. However, in addition, the firms in these clusters had to develop action plans to be undertaken by firms operating within the clusters, detailing the actions and timelines for improving environmental quality.

Failure to comply with action plans resulted in credible threats to their business. Firms could lose their Environmental Clearance and Consent to Operate permits, which allow them to function within the formal economy.[7] Moreover, Consent to Establish permits could not be issued to new operations if those operations did not fully comply with the cluster regulations and action plans. Of the 88 industrial clusters subject to the regulation in 2009, 43 industrial clusters in 17 states had a CEPI value of 70 or higher. A further 32 industrial clusters had a CEPI value between 60 and 70.

Recognizing that compliance requires large, lumpy investments, regulators explicitly acknowledged financial constraints—particularly among smaller firms—and paired enforcement with targeted subsidies and cost-sharing arrangements. As a result, action plans in $CEPI^{[70,100]}$ industrial clusters combined the firm mandates with publicly supported investments in abatement technologies and shared infrastructure. For instance, in the Ankleshwar industrial cluster in the state of Gujarat, this included subsidized and PPP-based investments in advanced treatment and disposal facilities, such as the proposed plasma-technology hazardous-waste incinerator (project cost Rs. 85 crores), for which state subsidies were sought to facilitate adoption. Further, for air pollution, the action plan emphasized technology-based abatement at the source, including leak detection and repair (LDAR) programs and upgrades to solvent recovery systems to achieve 95–99 percent capture of volatile organic compounds, alongside publicly coordinated investments in ambient air quality monitoring.

[7] All firms, except for those in a few nonpolluting sectors, must apply for and receive approval from their respective State-level Pollution Control Boards (SPCBs). New activities require a permit called Consent to Establish, while new activities and renewals require one called Consent to Operate (Bhat, 2010; Fenske, Haseeb, and Kala, 2023; Kapur and Khosla, 2019).

Crucially, these measures were tiered by firm size: smaller firms relied on subsidized common facilities, while larger ones had to install comparable abatement technologies at their own expense. Thus, in our empirical analysis, we exploit this heterogeneity in firm size to study how alleviating financial constraints through subsidies for abatement investments shapes firms' adoption of pollution-control technologies and to provide suggestive evidence on which firms win and lose from the regulation.

2 Data and Summary Statistics

2.1 Data

We hand-collected data on the 2009 regulation from policy documents published by the CPCB. These include cluster CEPI values and their corresponding components broken down by medium (air, water, and land). Additionally, we hand-collected data from two follow-up rounds of monitoring by the CPCB in 2011 and 2013 in clusters with a 2009 CEPI value at or above 70. These data also include information on institutional details, monitoring, and enforcement. See the Online Appendix C for more information.

In addition, we use several auxiliary datasets, widely established in previous research on India (Bertrand et al., 2002; Gopalan et al., 2016, 2007; Lilienfeld-Toal et al., 2012; Naaraayanan and Nielsen, 2021; Naaraayanan and Wolfenzon, 2024). These sources allow us to observe detailed product-level inputs and outputs (Bau and Matray, 2023; Goldberg et al., 2010) as well as industrial energy consumption (Martin, 2011; Sivadasan, 2009). The following paragraphs detail the source and construction of each.

Industrial Clusters. We hand-collected the location of more than 2,000 clusters by name—the near universe of industrial clusters in 2009. As industrial clusters are a dense agglomeration of small and medium-sized enterprises (SMEs), we map them to the most granular regional unit available across different datasets. Specifically, we standardize the cluster names, extract their location from Google API, and match them to PIN codes and cities.[8] For our primary analyses,

[8]We match the location of industrial clusters to the more granular PIN-code level in the business registration dataset. In India, a PIN code, which stands for Postal Index Number code, is used by the postal system to facilitate the sorting and delivery of mail. On average, a single post office serves an area of approximately 21 square kilometers

which use firm data, city is the most granular regional unit, and hence we assign the treatment at this level.[9] Through this procedure, we can match 61 of the 88 industrial clusters for which the CPCB released data on the CEPI score. Overall, the firms in our sample represent a significant share of economic activity, producing over 70% of output between 2005 and 2015.

Emissions Datasets. To measure cluster-level changes in air emissions, we rely on the Emission Database for Global Atmospheric Research (EDGAR). EDGAR is a comprehensive global database that documents human-caused emissions of greenhouse gases and other pollutants. We use the highest resolution data available: emissions measured in $0.1° \times 0.1°$ grids at a monthly frequency. These data have several advantages for assessing the impact of emissions. First, EDGAR's figures are derived independently, using consistent international statistics and an established IPCC methodology.[10] Second, the database disaggregates emissions by pollutant type. We use emissions data for nitrous oxide (NO_x), particulate matter less than 2.5 μm in diameter ($PM_{2.5}$), and particulate matter less than 10 μm in diameter (PM_{10}). Finally, the data separately report emissions from different sectors. This allows us to focus exclusively on industrial emissions. Importantly, this allows us to mitigate concerns about measurement error, such as emissions from agricultural activities, which includes crop burning. These features of the EDGAR dataset facilitate studying changes in emissions, a substantial limitation in prior research on environmental regulations in emerging markets (Greenstone and Jack, 2015).

We link emissions from EDGAR to exact locations of clusters identified from the policy documents. This involves two main steps. First, we define the area around each plant as a circle with a five-kilometer radius, creating what we refer to as a footprint. This footprint ensures that we attribute changes in air emissions to firms operating within distinct industrial clusters. Second, we apportion the monthly measurements from the grid to this footprint. If a footprint spans multiple grid cells, we calculate the pollution using a weighted average based on the respective land area of those cells. See Online Appendix F for details.

and a population of around 10,000.

[9] In most cases, we can uniquely match an industrial cluster to a city. However, in a handful of cases where this match is not unique, we aggregate CEPI values to the city level by assigning each city the maximum index value among all the industrial clusters.

[10] See https://edgar.jrc.ec.europa.eu/ and Crippa et al. (2019, 2020); European Commission, Joint Research Centre (EC-JRC)/Netherlands Environmental Assessment Agency (PBL) (2020) for more information.

We supplement these analyses with data on fine particulate matter ($PM_{2.5}$) from Van Donkelaar et al. (2015). These data are constructed by combining aerosol optical depth (AOD) data from several satellite sources and then calibrating the readings to pollution monitor data using a geographically weighted regression (GWR). The data are available monthly at the spatial resolution of 1km $\times$ 1km.

Firm Financials. We use firm and product data from Prowess, a database maintained by the Centre for Monitoring the Indian Economy (CMIE). Several studies on Indian firms have used this dataset, including Bertrand et al. (2002); Gopalan et al. (2007); Lilienfeld-Toal et al. (2012); Gopalan et al. (2016); Naaraayanan and Nielsen (2021); and Naaraayanan and Wolfenzon (2024). We extract data from the latest vintage of Prowess, which is free from earlier systematic survivorship bias, as highlighted by Siegel and Choudhury (2012).

The CMIE gathers data from balance sheets and income statements for approximately 37,000 publicly listed and private firms. The covered firms account for more than 70% of the industrial output, 75% of corporate taxes, and over 95% of excise taxes collected by the government of India and represent large and medium-sized firms in India (Bau and Matray, 2023).[11] Moreover, in addition to headline firm financial statements, the data also capture firm abatement expenditures, a proxy for one of the key levers the regulation used to reduce cluster emissions. Therefore, the data are particularly useful for examining how firms adjust over time in response to environmental regulations.

Product-level Inputs and Outputs. To study within-firm decisions, we use detailed product-level data made available due to *mandatory* disclosure requirements set out in the Companies Act of 1956 and the Companies Act of 2013. On the output side, the dataset captures total sales and total quantity sold at the firm-product level, allowing us to compute unit prices and quantities. In addition, it provides information on capacities, production, and sales from company annual

[11] Research on India has also used the Annual Survey of Industries (ASI) to examine the impact of reforms on the manufacturing sector. The most important difference is that Prowess is a firm-level panel dataset, whereas ASI is an establishment-level dataset that surveys a repeated cross-section of 30,000 establishments per year (Martin, 2011; Sivadasan, 2009). Therefore, ASI is limited in terms of panel coverage, making it ill-suited for studying within-firm responses to environmental regulations.

reports (see Goldberg et al. (2010) and Bau and Matray (2023) for details).[12]

There are approximately 2,300 distinct manufactured products in our final dataset, where the definition of a product is time-invariant. We follow Prowess's internal product classification, which in turn relies on the National Industrial Classification (NIC). Using these definitions, we construct a panel of product-level output and prices, with unit-level prices for each product defined as the total unit sales over total unit quantity. See Appendix Table IAA1 for information on the distribution of products and share of total manufacturing output for each NIC2 manufacturing sector.[13] Basic metals, vehicles, and chemicals account for the largest share of value, while furniture and other wood products have the lowest. These patterns on product distribution comport with those reported for samples of multi-product firms in the US (Bernard et al., 2010) and in India (De Loecker et al., 2016).

On the input side, Prowess captures product-wise energy consumption reported in company annual reports.[14] The data are at the firm-product-year-energy-source level and are expressed in energy input units per reported production unit. We transform energy input into CO_2 output by making assumptions about each energy source's energy content and CO_2 output. We calculate tons of CO_2 emitted per reported production unit for each firm-product-year-energy-source and collapse to the firm-product-year level across energy sources. (See Online Appendix G for details.) To our knowledge, no other data source offers comparable granularity and scope to understand the intersection of firm production and energy consumption.

2.2 Final Sample and Summary Statistics

Our aim is understanding the impact of regulation targeting pollution from industrial clusters, which feature dense agglomeration of manufacturers. Our estimation sample therefore comprises

[12]The Companies Act does not mandate or specify the units for reporting, leading to a lack of standardization both across and within firms over time. Therefore, we standardize units within and across firms and drop observations in instances where there is insufficient information to reconcile changes in unit types within a firm-product over time.

[13]Product codes are held fixed from 2008, except for when we explicitly test for extensive margin changes in firm product mix.

[14]Sub-section (1), clause (e) of section 217 of the Companies Act of 1956 stipulates that all companies must report their *total* energy consumption in a specified format. Nevertheless, there is no legal requirement for companies to disclose their product-specific energy consumption per production unit. Consequently, one limitation of the analysis on changes in product-level energy consumption is that firms can decide whether to disclose this information. Not all firms choose to do so. In Online Appendix G, we explore the representativeness of these data. Importantly, we observe in our data that, when a firm initiates the reporting of product-level energy inputs, it typically does so consistently throughout the entire period. Moreover, we find a reduction in the probability of filing energy inputs at all in the post-regulation period but no discontinuity in this probability at the treatment thresholds. See Appendx H.

manufacturers located in the 61 clusters for which we have a CEPI value. We focus on a five-year window around the 2009 regulation. Moreover, as we aim to study the within-firm response to the regulation, we focus on multiproduct firms, allowing us to better understand different margins of adjustment. These firms represent over 95% of the output during the sample period. This focus on multiproduct firms follows prior studies (Bernard et al., 2010; De Loecker, 2011; De Loecker et al., 2016; Eckel and Neary, 2010).

Table 1 presents the descriptive statistics for the sample of manufacturers from 2005 to 2015. Included firms are multiproduct manufacturers in industrial clusters assigned a 2009 CEPI value. Panel A reports summary statistics at the firm-year level. The average (median) firm has 3.5 (0.6) million INR in total assets and 3.3 (0.8) million INR in total sales.[15] The sample firms are, on average, moderately indebted, with average (median) leverage ratios (bank borrowing scaled by total assets) of 0.27 (0.25). The average (median) company derives 16.3% (1.6%) of its total sales from exports. The average (median) firm produces three (two) distinct products a year.[16] The average (median) firm is also moderately profitable, reporting 11% (10%) of the value of year-before sales in new earnings before interest, taxes, depreciation, and amortization. The listed firms in our sample have an average (median) market-to-book ratio of 0.88 (0.41).

[PLACE TABLE 1 HERE.]

Panel B of Table 1 describes the product-year-level panel dataset. The overall picture is of significant heterogeneity in operations. Product profit margins—defined as *(unit price - unit cost) / unit price*—tell us that the average (median) firm-product earns 0.01 (0.14) INR per unit produced. This granular evidence is consistent with the firm-level profitability distribution. Finally, the distribution of product sales, cost, and price are all highly skewed, as is the distribution of unit-level CO_2 emissions, calculated for those firms that report product energy inputs. Overall, the panel of manufacturers firms involves a broad cross-section of firms and describes industrial clusters composed of a few large firms and many medium-sized ones.

[15] As of March 2009, 1 USD was equivalent to 50.61 INR.

[16] We drop firms that produce one product throughout the sample but not those that switch between being single- and multi-product producers, so that we preserve variation at the extensive margin.

3 Empirical Strategy

Our empirical strategy exploits both the time variation around the introduction of the CEPI-based emissions regulation and the cross-sectional variation induced by the CEPI treatment thresholds. For the time variation, we exploit the difference across 2009, the year of the implementation of the regulation. For cross-sectional variation, we exploit the treatment effect crossing the two thresholds outlined by the CPCP, above and below 60 and above and below 70.

Specifically, we estimate:

$$Y_{ijcst} = \beta_1 Post_t \times CEPI_c^{[60,70)} + \beta_2 Post_t \times CEPI_c^{[70,100]} + \beta_3 CEPI_c + \beta_4 Post_t + \gamma_i + \kappa_{jst} + \epsilon_{ijcst}, \quad (1)$$

where i, j, c, s, and t index firm, industry, cluster (city), state, and year, respectively. Our running variable, $CEPI_c$, is the pollution index value, defined at the cluster level, as described in Section 2. The variable $CEPI^{[70,100]}$ takes the value one if the cluster has a CEPI value at or above 70 and zero otherwise. $CEPI^{[60,70)}$ takes the value one if the cluster has a CEPI value greater than or equal to 60 and below 70 and zero otherwise. The omitted category includes firms whose cluster has a maximum CEPI value below 60.[17] We assign firms to clusters using 2009 headquarters locations because financial statements are consolidated at the firm level.

The variable $Post_t$ is an indicator variable that takes the value one for all years including and after 2009—the year in which the CEPI regulation was implemented—and zero otherwise. We include firm fixed effects (γ_i) and state-by-industry-by-year fixed effects (κ_{jst}).[18] We cluster standard errors at the industrial cluster level, the level at which we define treatment (Abadie et al., 2023; Bertrand et al., 2004; Roberts and Whited, 2013).

The granularity of the data allows us to address concerns about location- and industry-specific effects that may differentially affect firms' production and emission decisions. We include firm fixed effects (γ_i) control for unobserved time-invariant firm characteristics. State-by-industry-by-year fixed effects (κ_{jst}) control for time-varying industry trends within the same

[17] In the final sample, 33 cities have a maximum CEPI value greater than or equal to 70 in 2009, and an additional 20 have a maximum 2009 CEPI value greater than or equal to 60 and below 70.

[18] The main effect of $CEPI_c$, which is invariant within a firm, drops out with the inclusion of firm fixed effects, while the main effect of $Post_t$ drops out with the inclusion of state-by-industry-by-year fixed effects.

state, for example, in emissions or emissions enforcement, or any fuel tariffs affecting an industry uniformly. The stringency of these fixed effects allows us to rule out several location- and industry-specific concerns, such as technical innovation and regulation, which vary considerably over states and industries. We cluster standard errors at the treatment-assignment level.

The coefficients of interest are β_1 and β_2. Specifically, β_1 quantifies the effect of being in a cluster with a CEPI value of at least 60 (monitoring only) on the outcome relative to the effect of being in a cluster to the left of the cutoff with a CEPI value below 60 while controlling for additional treatment from being in a cluster subject to a remedial action plan ($Post \times CEPI^{[70,100]}$). Similarly, β_2 quantifies the effect of being in a cluster with a CEPI value of at least 70 (monitoring plus mandated abatement) on the outcome relative to the effect of being in a cluster to the left of the cutoff with a CEPI value below 60 while controlling for the effect of the monitoring treatment ($Post \times CEPI^{[60,70)}$). We also report the pooled average effect of crossing the threshold, along with its associated t-statistic value. By comparing the outcomes of two firms making the same product in the same state in the same year, one of which is subject to environmental regulation and the other subject to lower (baseline) environmental regulation because its cluster's CEPI value is below 60, we can cleanly estimate the effect of the 2009 CEPI regulation.

3.1 Identification Assumptions

Our empirical strategy is a difference-in-differences (DiD) approach that exploits time-series variation emanating from the 2009 CEPI regulation, while the treatment and control groups are assigned based on pre-determined regulatory thresholds based on the CEPI values. In this specification, our primary identification assumption is that treated and control outcomes would have evolved in parallel in the absence of the regulation. We validate this assumption by documenting the lack of manipulation of the running variable and the absence of discontinuities in pre-treatment characteristics at the cutoff.

To formally assess the identification assumptions, we test for parallel pre-trends and the assumption that there is quasi-random variation to exploit from the cutoff rule. For the latter, we rely on the tests of the smooth potential outcomes assumption—that there would be no discontinuity in the outcome in the absence of the threshold— using tests from the regression

discontinuity literature.

First, we test for manipulation of the 2009 CEPI running variable. Panel A of Figure 3 plots the CEPI distribution with vertical lines at 60 and 70. We observe no bunching around the cutoffs. To formally test for bunching, we pool the two cutoffs by normalizing each cluster's score by its nearest threshold and implement the McCrary density test (McCrary, 2008). We find no bunching at the pooled cutoff; the two-sided p-value is 0.58.[19]

[PLACE FIGURE 3 HERE.]

Second, in Figure 4, we present the geographical variation in the industrial clusters selected by the CPCB for the environmental assessment relative to the location of all industrial clusters as of 2009 (gray dots). We find that the industrial clusters targeted by the CPCB are representative of clusters in general, with above- and below-threshold clusters coming from geographically proximate regions within each state.

[PLACE FIGURE 4 HERE.]

Third, we test that there are no discontinuous jumps in our key outcomes and firm and product characteristics at treatment thresholds in the pre-regulation year.[20] For example, ruling out a discontinuous jump would assuage concerns about alternative explanations, such as that some other policy may have affected firms at these cutoffs, instead of isolating the effect of the environmental regulation.

[PLACE FIGURE 5 HERE.]

Figure 5 presents the scatter plots of means of several firm- covariates, defined as of 2008, by different bins (each of size 1) around the pooled threshold. We normalize the thresholds to zero by subtracting their respective threshold values from the CEPI value of the industrial cluster. We find no evidence of discontinuities in baseline covariates. The characteristics we examine include total assets, total sales, leverage, exporting intensity, investment, wage bill, and market

[19] We have limited cluster observations to the left of the CEPI threshold at 60. As a result, we do not have enough power to examine the two cutoffs separately. Hence, to be consistent, we present results with normalized thresholds throughout these tests.

[20] This is a test of the assumption that potential outcomes are smooth around the cutoffs.

capitalization (for listed firms). Panel A of Table 2 demonstrates that none of these characteristics differ statistically across the cutoffs even in a regression setting.

[PLACE TABLE 2 HERE.]

Similarly, Figure 6 tests for discontinuities at the pooled thresholds for product-level covariates defined as of 2008. Again, we see no significant discontinuous jumps in the product characteristics. Panel B of Table 2 reports the associated average differences of products of firms in industrial clusters with CEPI values below versus above the threshold and the coefficient and associated p-value of the regression discontinuity specification at the threshold between $CEPI^{[60,70)}$ and $CEPI^{[70,100]}$ cluster status. There is no significant jump, either statistically or economically.

[PLACE FIGURE 6 HERE.]

Lastly, in Online Appendix Table IAA2, we examine whether there are discontinuous jumps in cluster-level covariates defined as of 2008, taken from the Population Census conducted in 2001 and Harari (2020). We again see no significant discontinuities in various proxies for economic activity—neither demand nor supply for goods—and determinants of the extent of pollution and its impact. The preponderance of evidence thus suggests that the treatment thresholds do not proxy for pre-existing differences in policies that affected firms in the same way as the environmental regulation.

In summary, we find no evidence of manipulation at the thresholds and no pre-treatment discontinuities in observables. We also find no evidence of diverging pre-trends (reported below). It is thus unlikely that other explanations could drive our findings; for that to happen, systematic differences between treated and control firms would need to align perfectly with the thresholds and the timing of targeting by the regulation, even after accounting for the relevant set of high-dimensional fixed effects, which control for firm and state-industry-year differences.

A remaining concern is that omitted variables affect the composition of industrial clusters. We address these concerns in Section 5.5, where we document no evidence of changes in mergers and acquisitions, which would enable firms to exit clusters in response to the stringent environmental regulations. We also do not observe differential plant closures or new starts among the treated firms. Another concern is spillovers across clusters: activity or emissions displaced from treated

clusters to control ones. Our firm and product analyses are estimated at the consolidated firm level so any within-firm shifting will be captured. Moreover, any activity or emissions displaced to controls would attenuate differences and bias our estimate toward zero.

Under our empirical specification, the primary identification assumption is that crossing the threshold, after controlling for the stringent set of high-dimensional fixed effects, the environmental regulation is as good as randomly assigned. We acknowledge that, under such a specification, it seems unlikely that other explanations could drive our findings; for that to happen, systematic differences between treated and control firms would need to align perfectly with the thresholds and timing of targeting by the regulation, even after accounting for the relevant set of high-dimensional fixed effects.

4 Changes in Cluster-Level Air Emissions

At the industrial cluster level, our primary outcome of interest is emissions As discussed in Section 2, we extract emissions data, measured in milligrams per month within a spatial resolution of 0.1°x 0.1°, from the EDGAR dataset.[21] We build a monthly panel of emissions from industrial activity split by the type of pollutant at the cluster-address level and estimate the following event study specification:

$$Emissions_{pcst} = \sum_{k \in \{-4,-2\}} \beta_k D_k \times CEPI_c^{[60,100]} + \sum_{k \in \{0,6\}} \beta_k D_k \times CEPI_c^{[60,100]} + CEPI_c + \gamma_{cp} + \gamma_{pst} + \epsilon_{pcst} \quad (2)$$

where p is pollutant, c is cluster, s is state, and t is year-month. Figure 7 plots the estimated coefficients (β_k), normalized to the fiscal year of 2008, and their corresponding 95% confidence intervals. This analysis compares the evolution of emissions in treated clusters relative to others. The vertical gray dotted line indicates the regulation year of 2009. Standard errors are clustered

[21] In contrast to previous research, which primarily relies on data related to particulate matter ($PM_{2.5}$), the EDGAR dataset have two key advantages. First, it provides information on a wide range of greenhouse gas emissions across a broad cross-section of industries. Secondly, the data are adjusted to separate emissions from fires and those stemming from industrial activities. This separation allows us to focus exclusively on industrial emissions, including fugitive emissions and solvents. These features of the EDGAR dataset make it well-suited to study changes in emissions, which has been a substantial limitation in prior research on environmental regulations in emerging markets (Greenstone and Jack, 2015).

at the address level.

[PLACE FIGURE 7 HERE.]

As evident from Panel (a) of Figure 7, there are no differential pre-trends in the average emissions from industrial activities between treated and control clusters. These results suggest that, in the pre-period, regulators were not targeting clusters that were already improving their air quality.[22] These parallel pre-trends support the identification assumption that outcomes of the treated and control groups would have evolved similarly, absent treatment, around the thresholds. Moreover, in the post-regulation period, there is an immediate and persistent decrease in the average emissions levels within treated clusters. In Panel (b) of Figure 7, we find a significant decrease in $PM_{2.5}$ emissions.

[PLACE TABLE 3 HERE.]

Table 3 presents these results in a regression framework. Column 1 combines all pollutants into a single regression and accounts for their differential impact by including high-dimensional fixed effects. These fixed effects interact cluster and state$\times$year-month fixed effects with the specific pollutant type. As in Figure 7, we find a statistically significant decrease in relative emission levels for treated clusters compared with industrial clusters having a CEPI value below 60. In terms of the economic magnitude of β_1, clusters with CEPI pollution index values just to the right of 60 have 7.232 mg per month lower pollution, representing a 31.3% decrease relative to the pre-treatment average total pollution of clusters with CEPI just less than 60 of 23.09 mg per month. Note that this effect is relative to the cluster's own mean and controls for state-year-month trends in pollution, such as from production seasonality.

From the table, we see that the effect is statistically indistinguishable in clusters with 2009 CEPI value of at least 70 and in those with values between 60 and 70. This suggests that continuous monitoring by regulators led to the immediate reduction in emissions, while action plans likely work better in the longer term.[23] This immediate reduction resembles the dynamics we presented in Figure 7, which showed a significant emissions reduction. Lastly, the average treatment

[22] For this analysis, we pool emissions data across the following pollutants: NO_x (nitrogen oxides), $PM_{2.5}$, and PM_{10}. This figure complements our previous finding of no ex ante discontinuities in the aggregate in Figure 5.

[23] As we note in Online Appendix C, finalizing the action plans took up to a year, and these typically mandated the implementation with timelines varying up to three years.

effect from the pooled-treatment specification highlights the importance of continuous monitoring.

At the same time, we do not observe a significant difference between the coefficients across industrial clusters with varying levels of enforcement intensity, as suggested by the p-value testing the difference between β_1 and β_2. However, this average reduction in cluster-level emissions masks significant heterogeneity. Therefore, in Online Appendix E, we set out to better understand the determinants of compliance, and we hand-collect information on follow-on assessments and relate it to regulator characteristics. We find that cluster improvements are positively associated with regulator quality and enforcement capacity, a greater proportion of small firms, and public-private cost sharing for abatement investments. These findings support prior work that argues for the importance of regulators in achieving emissions reductions in environments with low state capacity and large information asymmetries (Duflo et al., 2013; Pande and Datla, 2016).

In the remaining columns of Table 3, we separate the estimates by pollutant type. We chose the pollutants highlighted in the section of the action plans devoted to air emissions. Across the columns, we find a similar decrease across different pollutants.

In Panel (b) of Online Appendix Table IAA3, we re-estimate our specification using satellite measurements of fine particulate matter ($PM_{2.5}$) at a more granular, 1km $\times$ 1km, resolution (Van Donkelaar et al., 2015). We find a statistically significant decrease in relative emission levels for treated industrial clusters in a five-kilometer and 500-meter radius around the center of each cluster. Relative to the pre-regulation mean in the control group, this change represents a 4.0% decrease, significant at the 95% confidence level.[24]

Finally, to rule out unobserved time-varying trends, we use the EDGAR dataset to conduct a placebo test on emissions from agricultural crop waste burning in treated versus control clusters. These were not targeted by the regulation. As shown in Online Appendix IAA4, we find no economically or statistically significant change in their emissions. This suggests that background trends do not explain our results and that the targeted firms lowered emissions specifically due to the regulation.

[24]The differences in economic magnitude relative to the results presented in Table 3 are likely an artifact of the low correlation between $PM_{2.5}$ readings across the two datasets (ρ = -0.06). These differences could arise from variations in calibration methods, differences in spatial resolution, and the level of industrial activity captured. We believe that, given the low correlation, both data sources provide orthogonal measurements that help establish a robust reduction in emission levels in response to the CPCB regulation.

5 Greening Production and Abatement Investments

In this section, we examine the margins through which firms reduce their pollution. We first consider whether firms reduce their level of production or improve their energy efficiency. The results suggest that firms achieve reductions primarily through efficiency gains rather than lower output. We then investigate specific changes in inputs and outputs that drive the lower baseline pollution in treated clusters. Finally, we study other margins of adjustment, specifically documenting that firms significantly increase abatement expenditures to curtail their pollution. We further corroborate these findings with complementary evidence from annual reports and regulatory action plans. Overall, our analysis suggests that firms green their production and invest in abatement technology in response to the regulation.

5.1 Energy Efficiency

We begin by examining changes in production and energy inputs at firms within the industrial clusters. Panel A of Table 5 shows the impact of the regulation on firms' energy inputs, controlling for the per unit cost of production. In column 1, the dependent variable is the natural logarithm of the quantity produced at the firm-product-year level. We do not find a difference between the treated and control groups around the reform in either cluster. In column 2, however, when studying energy expenditures at the firm-year level, we find that it is lower for firms operating in both clusters. In terms of economic magnitude, the reduction is approximately 22% on an annual basis. Relative to the 2008 average energy expenditure of 8.906 million INR per product, this represents a reduction of about 5.6 million INR, equivalent to $124,740 (in 2008 U.S. dollars). Overall energy use declines while production does not, suggesting that treated firms respond by improving the energy efficiency of their production.

[PLACE TABLE 5 HERE.]

5.2 Fuel Inputs

We next investigate specific changes in inputs and outputs that drive the lower pollution levels in treated clusters. One possibility is that, in response to the regulation, firms re-optimize energy use by either changing their fuel composition (i.e., moving away from coal) or switching from

carbon-intensive self-generation to purchasing power from the grid. Panel B of Table 5 reports *within-firm-product* estimates of how firms change their energy inputs around the regulation.

Column 1 suggests a considerable decrease of 29% in the use of coal as a product input in firms in $CEPI^{[60,70)}$ clusters relative to firms in clusters with CEPI just to the left of 60. This represents a drop from 17% of inputs to 10% of inputs for the average product, relative to the control use of coal as an input per product. In Column 2, we examine whether firms increase the proportion of energy purchased from the grid, which tends to be less carbon intensive than on-site self-generation.[25] Estimates in Column 2 suggest that firms do shift from to purchasing energy. Specifically, the average treated firm located in the cluster right above 60, relative to firms located right below 60, increases the proportion of energy that it purchases from the electrical grid by 19.6 percentage points.[26]

Lastly, we use data on product energy consumption by fuel source to compute emissions. Appendix Table 4 reports whether product-level CO_2 emissions decrease alongside energy input changes. Following the literature, we convert energy inputs into CO_2 output based on assumptions about each source's energy content.[27] To be conservative, we treat all electricity as coal, biasing against finding an effect. We calculate tonnes of CO_2 per production unit for each source and then collapse to the firm-product-year level. Emissions fall sharply relative to control firms, suggesting that they re-optimize their fuel inputs to comply with the regulations.

5.3 Changes in Product Portfolio Composition

We examine a third margin of adjustment — if firms change the composition of product portfolios, which may drive the baseline reduction in pollution. Panel A of Figure 8 plots the effect over time on the weight of the treated firm's highest-emission product (in 2008), relative to control firms. Emissions are calculated using fuel-specific CO_2 conversion factors, as in Appendix Table 4. We normalize coefficients to one period before the regulation. We find that the weight on the highest-emission products falls, on average. Panel B uses the weight on the highest coal-use

[25] During the sample period, coal was the primary source of electricity generation, accounting for roughly two-thirds of total electricity generation in India. The share of renewables in electricity generation during this period remained stable at 20%—calculated using data from International Energy Agency.

[26] Firms in emerging markets, including India, often rely on their own power generation, even when it is less efficient or costliert. They do so to reduce their exposure to unreliable external power supply (Allcott et al., 2016; Cole et al., 2018; Fried and Lagakos, 2023).

[27] See Section 2.1 and Online Appendix G for more details.

product and shows nearly identical dynamics.

[PLACE FIGURE 8 HERE.]

We complement the figure using estimates from a regression analysis, presented in Table 6. In column 1, we find a significant shift in firms' portfolios away from their highest-emission products. Estimates suggest that firms reduced the weight of these products by 15.9 percentage points, which, relative to the pre-period control group's sample mean of 0.65, represents a decline of nearly 25%. Further, column 2 studies the weight of the product with the highest proportion of coal in its energy input mix. Estimates here suggest a 16.2 percentage point decline. Scaled by the pre-period control group's sample mean of 0.82, this translates to nearly a 20% reduction.

[PLACE TABLE 6 HERE.]

Taken together, the estimates in this section indicate that firms improve their energy efficiency, change fuel inputs, and adjust their product portfolios to comply with the regulation. While these measures enhance environmental performance, it remains unclear whether such changes would have occurred absent regulation. Prior work points to significant optimization frictions; firms across the size distribution, including many SMEs, often face barriers such as financial constraints, information asymmetry, and limited exposure to competition (Sivadasan, 2009).

5.4 Abatement Expenditures

As a fourth margin of adjustment, we study abatement expenditures undertaken by firms to comply with the regulation. As a reminder, the regulation required firms operating in industrial clusters with CEPI values exceeding 70 to formulate comprehensive action plans, which necessitated explicit capital investments in abatement. Importantly, as mentioned in Section 1, the government subsidized these investments for smaller firms. Since these action plans are publicly available, we use them to identify and corroborate the specific technologies underlying these investments, allowing us to illuminate regulatory compliance directly to observable capital allocation decisions.

5.4.1 Average Effects

To ascertain whether firms in the targeted industrial clusters invested in abatement, we rely on expenditures for pollution control equipment, as captured in financial statements.[28] Note that this is also the best available proxy for firm exposure to regulation-imposed investment mandates because it captures the portion of firm expenditures that contributes to cluster-wide investment.

Panel A of Table 7 examines the changes in abatement expenditures around the environmental regulations. We find that firms increase their abatement expenditures, on average, both on the extensive and intensive margins. Specifically, column 1 reports the extensive margin response. Column 1 examines the extensive margin, defined as $1_{Abatement}$, an indicator that takes the value one if the firm's abatement expenditure as a fraction of total assets is nonzero and zero otherwise. We see that only firms in the clusters with a CEPI value of at least 70—those subject to action plans mandating emissions-reducing investment—significantly increase their likelihood of investing in abatement relative to firms in control clusters. Note that the coefficients between the two treatment groups are statistically significant at the 95% confidence level. The interpretation relative to the 2008 level of abatement among firms in control clusters is a 7.7 percentage point increase in the probability of investing in abatement from 4.8% to 12.5%.[29]

[PLACE TABLE 7 HERE.]

Column 2 examines the intensive margin, defined as abatement expenditure scaled by firm assets. Firms in clusters with CEPI value between 60 and 70 increase their abatement expenses as a ratio of their total assets by approximately four percentage points relative to control firms in clusters with a CEPI just below 60. This is a large effect; at baseline, control firms spent 1.4% of the value of their assets on abatement. Online Appendix D presents supplementary evidence on specific abatement investments mandated by the action plans and as reported by firms in their audited annual financial statements.

While these estimates from financial statements show that firms are increasing both the ex-

[28] Abatement investments include technology adoption, energy-efficiency enhancing changes such as retrofitting boilers, process upgrades such as installing scrubbers, and other activities that often require re-optimizing inputs.

[29] One might be concerned that firms are increasing reclassifying capital expenditures as abatement expenditures that they were going to make anyway to lower emissions. To assuage this concern, in Online Appendix Table IAA5, we show that treated firms do not change their physical investment differentially relative to control firms or other production inputs.

tensive and intensive margins of abatement investments, they are silent on which technologies they adopt. To explore this, we analyze the text of the publicly available action plans. We employ a large language model (LLM) to extract sentences detailing abatement investments and technologies installed to reduce pollution. We visualize the distribution of these technologies in Figure 9; the methodology for this text extraction is provided Online Appendix D.1. The figure reveals substantial heterogeneity in abatement strategies. Specifically, we document a reliance on source reduction—interventions that eliminate pollution prior to recycling or disposal—and process improvements. These proactive measures, which include the use of less toxic materials and water conservation, prioritize waste minimization over simple end-of-pipe treatments. Furthermore, when analyzing the data separately by state, we document significant geographic variation in the types of technologies deployed.

Overall, we find that the regulation led to an aggregate reduction in cluster emissions through firms decreasing per-unit energy use, reallocating their energy inputs, and investing significantly in abatement technologies, especially those that were mandated to undertake these investments through remedial action plans.

5.4.2 Heterogeneity in Abatement Investments

As discussed in Section 4, clusters' improvements are positively associated with a greater proportion of small firms and with public–private cost sharing for abatement investments. Smaller firms typically face tighter financial constraints and are likely more sensitive to upfront abatement costs. Examining heterogeneity by size therefore helps explain the observed cross-cluster variation in emissions reduction while highlighting the importance of subsidies and cost-sharing arrangements in facilitating compliance.

To test this, we use the natural logarithm of total assets as reported in firms' financial statements. Each year, we rank firms by size and assign percentile scores from 0 to 100. Because smaller firms are generally more financially constrained, we invert the percentile so that higher values correspond to greater constraint. We then compute the time-series average of these inverted percentiles over the fiscal years preceding the policy period to obtain a pre-determined measure of firm size. Firms with an average-size percentile above the median are classified as

small using this proxy.

Panel B of Table 7 presents the results from this exercise. Column (1) shows that, on the extensive margin, firms invest in abatement in regions mandating action plans (i.e., those classified above 70). Importantly, this pattern of initiating new abatement strengthens for smaller firms in these regions. Regarding investment intensity, column (2) suggests that levels are similar between large and small firms. Together with our cluster estimates, this table highlights the importance of subsidies and cost-sharing to facilitate compliance where state capacity and information are limited.

5.5 Ruling Out Emissions Shifting

We consider the possibility that firms are shifting emissions out of treated clusters. Firms may relocate or expand their operations to regions with less stringent environmental regulations, particularly those related to environmental compliance (Copeland and Taylor, 1994, 2004). Research has documented that localized policies shift emissions within and across geographies (Bartram et al., 2022; Ben-David et al., 2021).

We consider several ways firms might shift their emissions. First, we consider whether firms in the targeted industrial cluster are more likely to acquire or merge with firms outside the cluster. In Online Appendix Table IAB6, we present estimates suggesting that the average likelihood of being a target or acquirer in a merger or acquisition is not affected by the reform.

Second, we consider whether firms relocate their production by expanding capacity elsewhere. To do this, we use data on the announcement of new and abandoned plants from the CapEx database maintained by CMIE.[30] In Online Appendix Table IAB7, we provide evidence suggestive that, on average, firms are unlikely to announce new plant constructions or to abandon the expansion of an existing plant.

Third, we consider firms shifting emissions through changes in factors of production. Note that, in the data, we observe product-level production at the firm-year level (not only within treated clusters), but within-firm relocation across clusters is inherently captured. Our estimates

[30]This dataset contains information on all new and abandoned plants announced in India since 1990. CMIE obtains data from multiple sources, including annual reports, news articles, and government press releases. Typically, projects costing more than INR 100 million (approximately USD 2 million) are included in the database (Alok and Ayyagari, 2020; Naaraayanan and Wolfenzon, 2024).

suggest significant improvements in energy efficiency through lower energy expenditures with no commensurate reductions in production. In contrast, we find no change in raw material expenses, wage bill, and capital investment. Taken together, these findings suggest that firms, on average, do not shift emissions through their labor or product markets.

Finally, we consider the possibility that small and large firms differ in their ability to shift emissions across plants. Since larger firms often operate multiple facilities while small firms typically operate just one, we hypothesize that larger firms are more likely to shift emissions across plants in response to regulation. However, the estimates presented in Appendix Figure IAB1 suggest no significant difference across firm sizes, inconsistent with within-firm shifting.

6 Costs of the Regulation

In this section, we examine the cost of the CEPI regulation by studying its implications for creative destruction through firm entry and product variety.

6.1 Reduction in Dynamism

A motivation for organizing manufacturing as part of an industrial cluster is to boost firm productivity through economies of scale and agglomeration externalities. We focus on firm entry as a summary measure of the agglomeration benefits since it reflects the net benefits and costs of agglomeration in a given industrial cluster.

To study firm entry, we use the near-universe of firm registrations from the Ministry of Corporate Affairs (MCA), allowing us to track business formation across all formal firms in the economy. Note that, since the data allow us to observe the universe of all formal firms, not just manufacturers, they allow us to capture the entire distribution of firm size operating in the formal sector and therefore spillovers between industries within these industrial clusters.

[PLACE TABLE 9 HERE]

Using this data, Table 9 reports estimates of firm entry at the cluster level. The estimates in Panel A suggest that the regulation decreases firm entry, driven by the effect in $CEPI^{[70,100]}$ clusters. Column 1 presents a linear probability model on the incidence of new firm creation.

We see an approximately 1.4% drop in new firm registrations, relative to the baseline rate of 7%. The effects are significant at the 90% confidence level in clusters with a CEPI of at least 70. Column 2 presents a model with the levels of the number of firms in each cluster as the outcome and estimates a Poisson model instead of ordinary least squares (Cohn et al., 2022; Silva and Tenreyro, 2006). Across the columns, we find a significant reduction in firm entry across all sectors within the most regulated industrial clusters.

In panel B of Table 9, we repeat the exercise using only firms in the Prowess database, which are typically larger than the average formal firm in the economy. These are also the firms in our regression sample. In this subsample, firm entry also significantly decreases with an economically meaningful magnitude relative to the ex ante pattern in control firms. These findings, together, highlight an important cost of the environmental regulation.

6.2 Product Variety

Next, we consider another potential cost: changes in product lines, which is an important metric from a social standpoint (Bils and Klenow, 2001; Feenstra and Kee, 2004; Klemperer and Padilla, 1997). Specifically, we examine changes in firm output at the product level. The expected effect is ambiguous: while the upstream manufacturers in our sample likely rely on sticky, long-term supply relationships, the observed changes in energy inputs suggest firms are re-optimizing production, which may extend to output adjustments.

We test these possibilities and report the results in Table 8. Estimates in Column 1 suggest no differential response, on average, between the production on the intensive margin of firms in treated and control clusters, as proxied for by the natural logarithm of the product-level production quantity. Estimates in Column 2 suggest no evidence of any differential extensive margin response, proxied for by the natural logarithm of the number of product lines at the firm level.

[PLACE TABLE 8 HERE.]

In columns 3 and 4 of Table 8, we test the effect on product variety. In aggregate, treated firms are significantly less likely to introduce new products. Specifically, firms in the highest-treatment clusters have a 12-percentage point lower probability of introducing a new product in the five years following the 2009 regulation. The probability of dropping a product is positive

but statistically insignificant. Overall, while there is no significant impact on firm production, we find a suggestive negative impact on long-term product variety, which has been recognized as a key source of consumer welfare since Bresnahan and Gordon (2008).

In summary, we document a decrease in firm entry across the size distribution, suggesting that compliance costs were sufficient to deter business formation. These findings may reflect lower competitive pressure and fewer agglomeration benefits within treated clusters. Combined with the evidence of decreased product variety. Our results contribute to the literature showing that regulation can lower emissions but at a tangible economic cost.

7 Back-of-the-Envelope Cost–Benefit Analysis

In this section, we construct a back-of-the-envelope (BOTE) estimate of the benefits and costs of the 2009 CEPI regulation. We focus on the benefits arising from avoided mortality due to reduced pollution exposure, a first-order benefit of environmental regulation. Note that our analysis centers on clusters with a CEPI score above 70 and computes the benefits arising from changes in air emissions, given our ability to measure them more precisely. This results in a conservative estimate of the benefits accruing to local population centers.

7.1 Benefits: Mortality Reductions From Lower Air Emissions

The mortality benefits are a function of three factors: (i) the reduction in pollution, (ii) the exposed population, and (iii) the pollution-mortality elasticity. We list each of them below.

The first factor is the impact of the regulation on air pollution, specifically fine particulate matter ($PM_{2.5}$). We estimate that industrial clusters subject to regulation experienced an average reduction in ambient $PM_{2.5}$ concentration of 1.96 $\mu g/m^3$ relative to control clusters. We use air quality estimates derived from satellite data Van Donkelaar et al. (2015), as they provide the most precise spatial coverage and an independent assessment.

The second factor is the exposed population. In our setting, we approximate the population benefiting from these improvements by considering residents within the 42 treated clusters. Using district population density from the 2001 Census (averaging 8,632 persons per km^2) and an average area footprint of 187.8 km^2, we estimate an average population of 1.62 million per cluster,

yielding an effective exposed population of approximately 68 million.

The third factor is the elasticity of the decrease in air emissions on mortality risk. We rely on the meta-analysis by Pope III et al. (2020), which implies a 0.5% reduction in all-cause mortality risk per 1 $\mu g/m^3$ decrease in fine particulate matter. Combining our estimated pollution reduction of 1.96 $\mu g/m^3$ with this semi-elasticity implies a 0.98% reduction in all-cause mortality.[31] Applying this reduction 2008 death rate of 7.4 deaths per 1,000 people from Office of the Registrar General & Census Commissioner, India (n.d.) yields an estimate of roughly 4,956 lives saved annually across the 42 clusters. Valuation of these lives using a $700,000 Value of Statistical Life (Majumder et al., 2018) yields total mortality benefits of approximately $3.47 billion per year (2009 U.S. Dollars).

7.2 Costs: Impact on Regulated Firms

We next quantify the costs borne by firms. Specifically, we consider the costs associated with direct abatement expenditures, changes in energy inputs, and the effects on business dynamism from reduced firm entry.

First, we examine abatement expenditures. Our estimates indicate that treated firms increased the ratio of abatement expenditures to total assets by 3.9 percentage points. Aggregated across the treated clusters, this corresponds to an annualized capital cost of approximately $1.58 billion.[32]

Second, we examine changes in energy inputs at the firm level. Treated firms reduced total energy consumption while maintaining production levels. While these efficiency gains yielded aggregate net savings of approximately $0.06 billion per year, the accompanying shift to grid-purchased electricity increased exposure to power supply instability. We estimate the cost of this reliability risk to be approximately $0.20 billion annually.

Third, we consider the effects of the regulation on firm dynamism, which in our setting is reflected in lower firm entry into the industrial cluster. New firm registrations in treated clusters declined by 1.4 percentage points from a 7% baseline, representing a 20% reduction. Assuming

[31] An alternative possibility is that the exposure-to-mortality relationship is concave at high pollution levels (Cropper and Park, 2022). Under this assumption, marginal reductions may yield negligible health benefits. We discuss this scenario in the comparison below.

[32] We estimate the aggregate cost by multiplying the coefficient (0.039) by the average total assets of firms in the treated clusters and scaling by the total number of treated firms.

each lost entrant represents $6.5 million in annual value added, this decline implies a loss of $0.56 billion in local economic activity per year. Therefore, the total annual cost of the regulation amounts to approximately $2.28 billion.

7.3 Comparison of Benefits and Costs

Comparing the benefits of reduced mortality to the estimated costs, the CEPI regulation appears cost-effective. The annual mortality benefits of approximately $3.47 billion exceed total estimated annual costs of $2.28 billion by a factor of 1.52.

How do these estimates compare with other pollution reduction interventions in India? Installing scrubbers at coal-fired power plants saves lives at a cost of approximately $400,000 per life (Cropper and Park, 2022). Conversely, payments for ecosystem services to reduce crop residue burning achieve reductions at a cost of roughly $3,000 per life saved (Jack et al., 2025). The CEPI regulation, with an implied cost per life saved of $460,000, approximates the scrubber benchmark.

Thus, even when accounting for tangible costs to firms and reduced business dynamism, the welfare gains from reduced pollution were significantly larger. The policy's design—combining enforceable action plans with monitoring—achieved significant environmental benefits at a manageable social cost.

8 Conclusion

There is growing emphasis and interest among policymakers on place-based emissions regulations to curb the effects of climate change. Against this backdrop, our paper demonstrates that firms may respond to emission caps by reorganizing production rather than shifting emissions, especially in emerging markets. Specifically, we document that treated firms achieved significant energy efficiency gains by reducing their energy expenditures without a commensurate change in their output levels. On the input side, firms reduce their reliance on coal and shift to purchasing electricity from the grid. Firms also rebalance their product portfolios away from high-emission, coal-intensive products while increasing their investment in pollution abatement. However, these benefits are offset by tangible costs to both business dynamism and product variety. Despite these costs, our back-of-the-envelope analysis suggests the regulation is cost-

effective, with annual mortality benefits of approximately $3.47 billion. That exceeds the total estimated annual costs of $2.28 billion by a factor of 1.5.

By documenting within-firm production decisions, this paper opens the "brown box" of how firms respond to environmental regulation. Our findings highlight that measuring these granular responses is critical, as distinguishing between input substitution and operational efficiency helps illuminate the true economic costs of compliance. These specific margins of adjustment determine whether observed outcomes reflect costly distortions or efficient responses, with direct implications for the green transition.

For industrializing economies balancing growth with decarbonization, our results highlight that financial considerations help drive the adoption of abatement technology. Compliance is highest when credible enforcement is combined with public-private cost sharing, particularly for small and medium-sized enterprises. The observed shift toward grid electricity further suggests that policymakers must coordinate sectoral policies both on the supply and demand sides to ensure a smooth transition. Ultimately, successful policy requires coordinating sectoral shifts and aligning financial support with place-based targets to ensure that abatement technology adoption remains both achievable and efficient.

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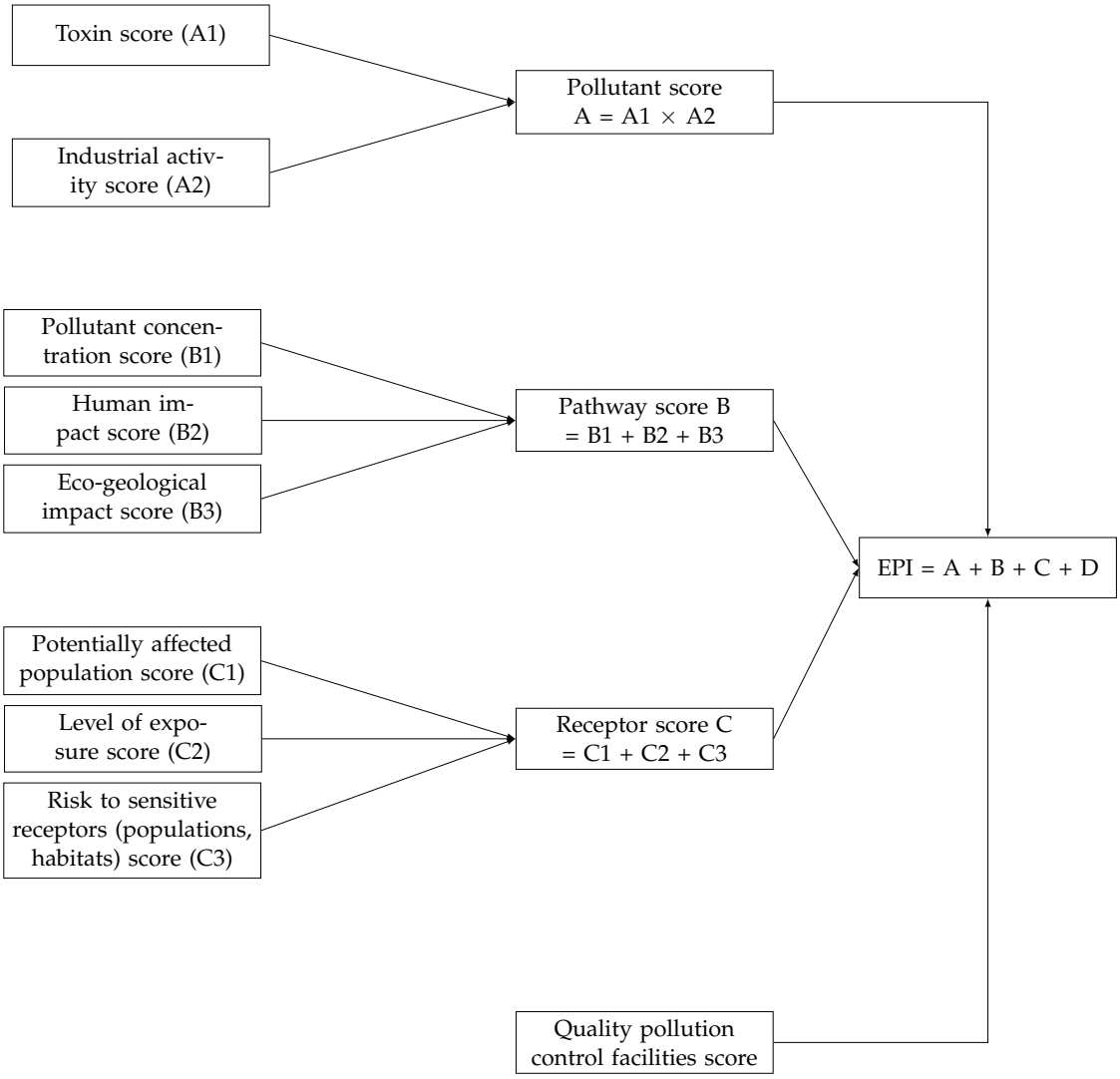
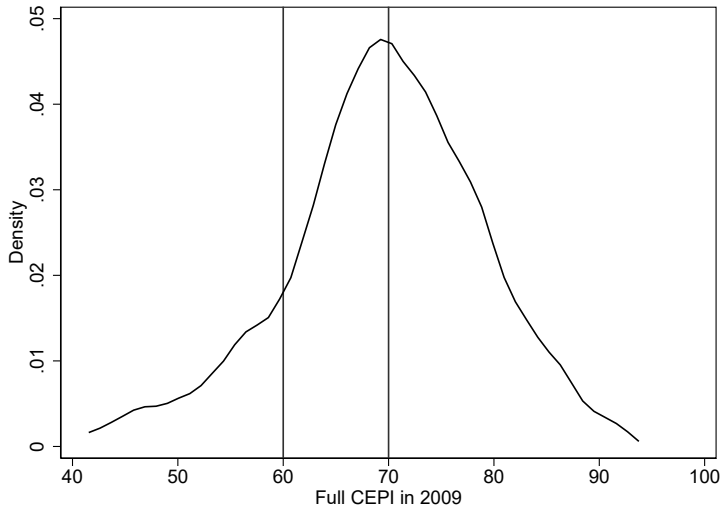
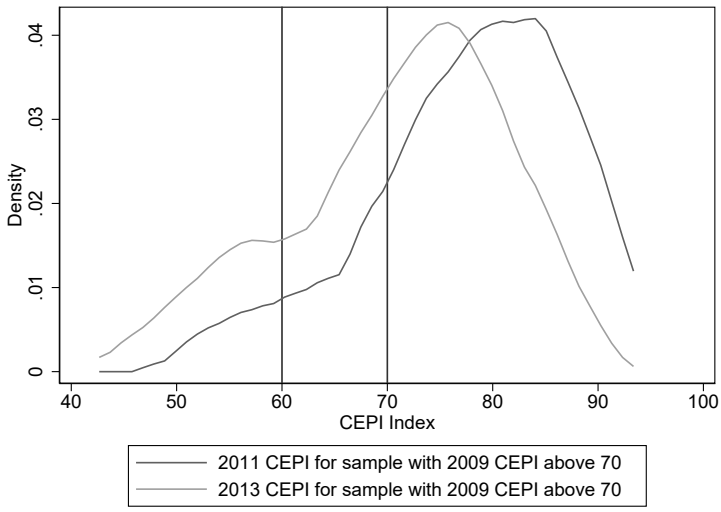


FIGURE 1: THE COMPREHENSIVE ENVIRONMENTAL POLLUTION INDEX

This figure presents the components of the Comprehensive Environmental Pollution Index (CEPI) as it was defined between 2009 and 2016. Calculations are at the industrial cluster level. Source: Central Pollution Control Board.



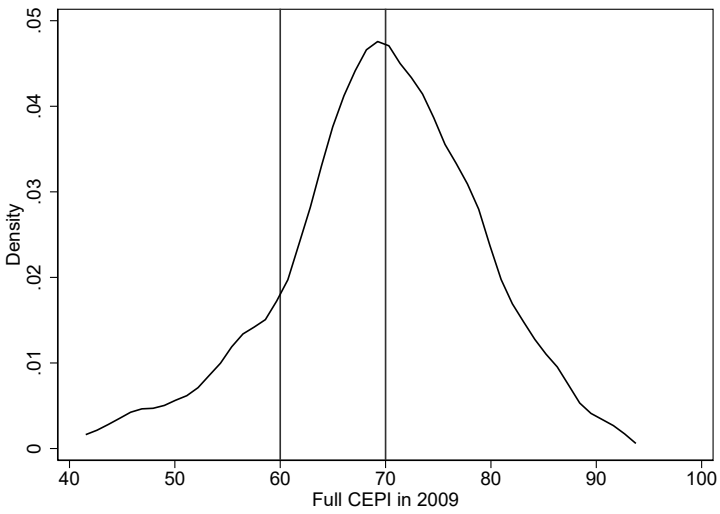
(a) CEPI in 2009



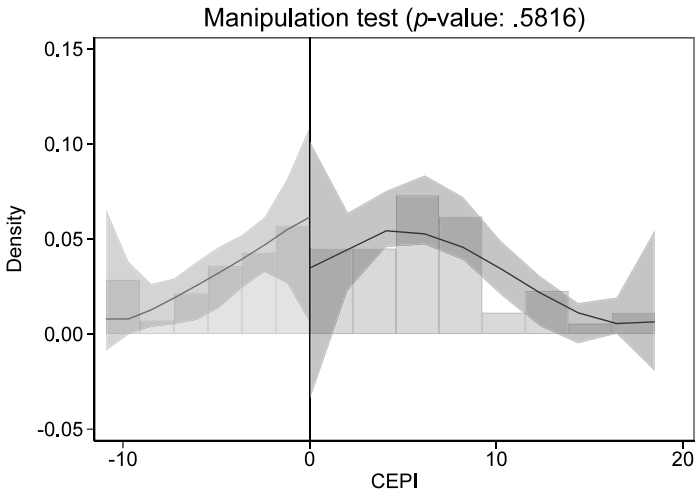
(b) Comparison between 2011 and 2013

FIGURE 2: EVOLUTION OF THE RANKING VARIABLE

This figure illustrates the evolution of the CEPI. Panel A presents the ranking distribution of 88 industrial clusters with CEPI values computed by CPCB in 2009. The vertical line marks treatment thresholds at CEPI = 60 and CEPI = 70. Panel B displays the CEPI distribution in 2011 (solid line) and 2013 (dashed line) government studies, focusing on the subset of clusters initially classified with CEPI values > 70 in 2009.



(a) Distribution of 2009 CEPI



(b) McCrary density test of 2009 CEPI at pooled cutoffs

FIGURE 3: TESTING FOR MANIPULATION OF THE RANKING VARIABLE

This figure tests for manipulation of the 2009 CEPI. Panel A presents the ranking distribution of 88 industrial clusters with CEPI values computed by the CPCB in 2009. The vertical line marks treatment thresholds at CEPI = 60 and CEPI = 70. Panel B displays the estimated density functions around the pooled thresholds at the CEPI values of 60 and 70. The *p*-value is from a two-sided test with the null hypothesis that the distributions of the rankings do not differ across the cutoff (Abadie and Cattaneo, 2018; McCrary, 2008)

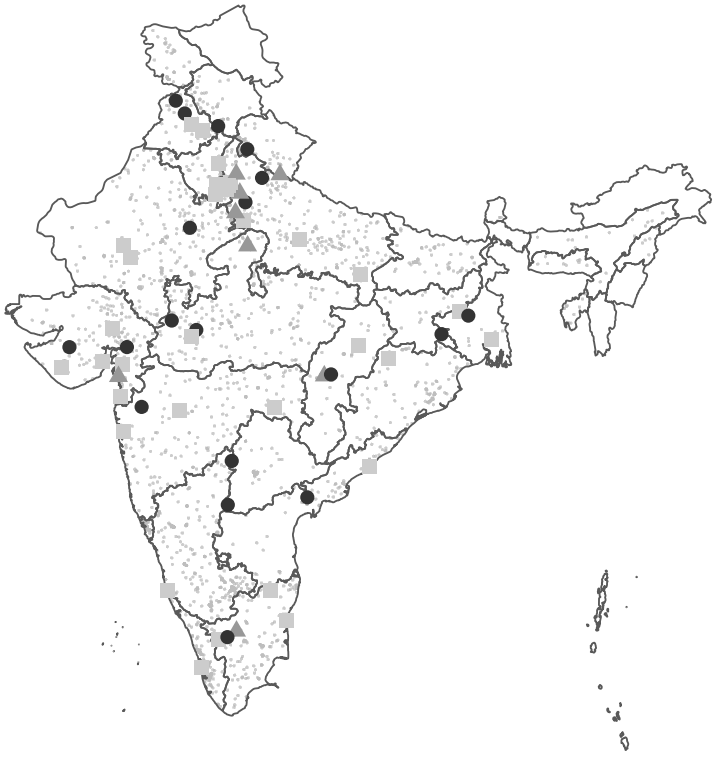


FIGURE 4: GEOGRAPHIC VARIATION OF INDUSTRIAL CLUSTERS

This figure presents the geographic variation of all industrial clusters as of the year 2009. Small gray dots illustrate the location of all industrial clusters. Larger black circles correspond to clusters with CEPI values at or above the 70 threshold, triangles correspond to clusters with index values between the 60 and 70 thresholds and squares correspond to clusters with index values below the 60 threshold.

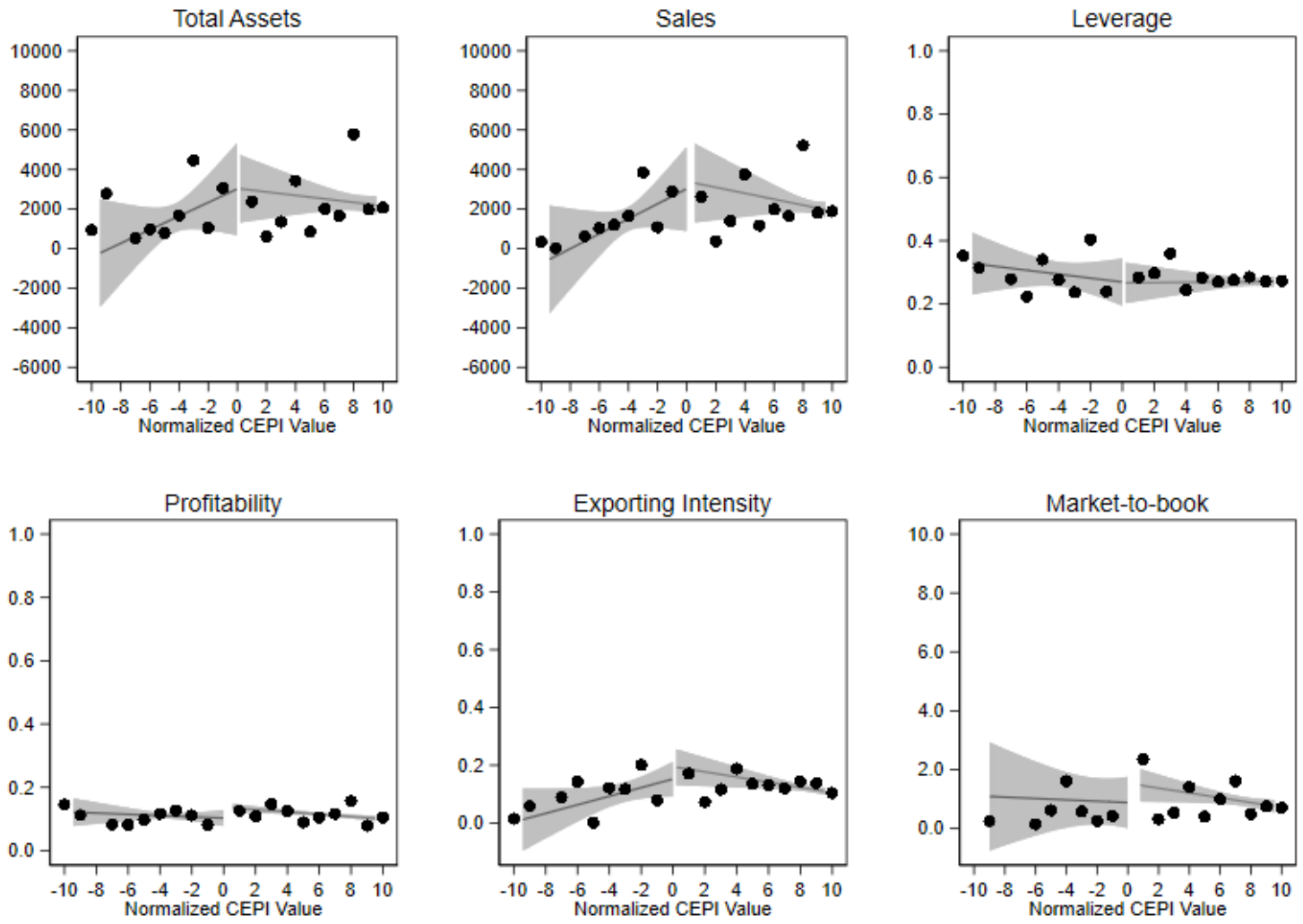


FIGURE 5: FIRM CHARACTERISTICS PRIOR TO THE INTRODUCTION OF THE CEPI

This figure presents regression discontinuity estimates of baseline firm characteristics from 2008, a year before CEPI regulation was introduced. It graphs the average firm characteristic in CEPI bins near the cutoff, pooling data across the CEPI thresholds of 60 and 70, marked as zero in the figures. A linear fit is generated separately for each side of 0, with the 95% confidence intervals displayed.

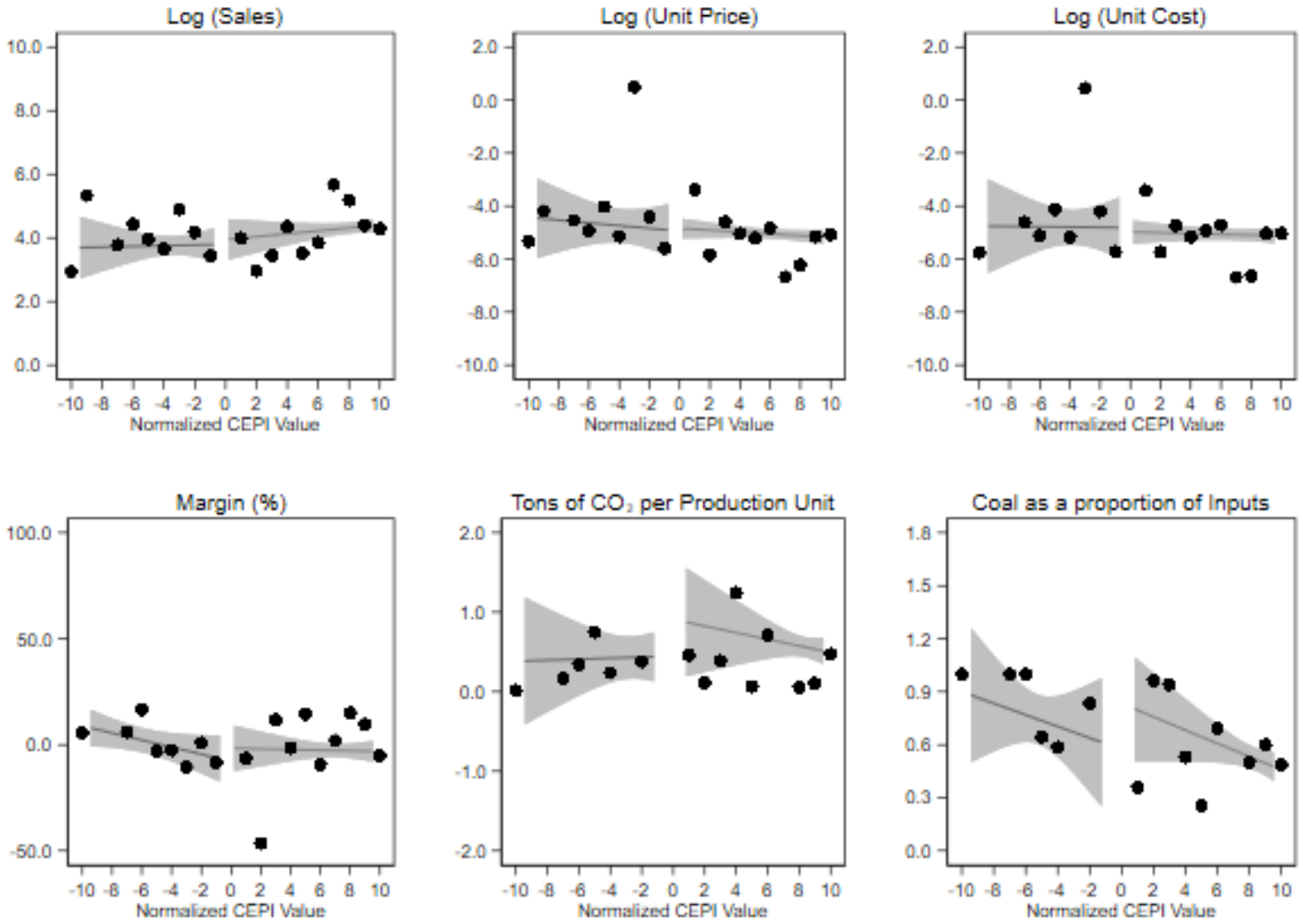
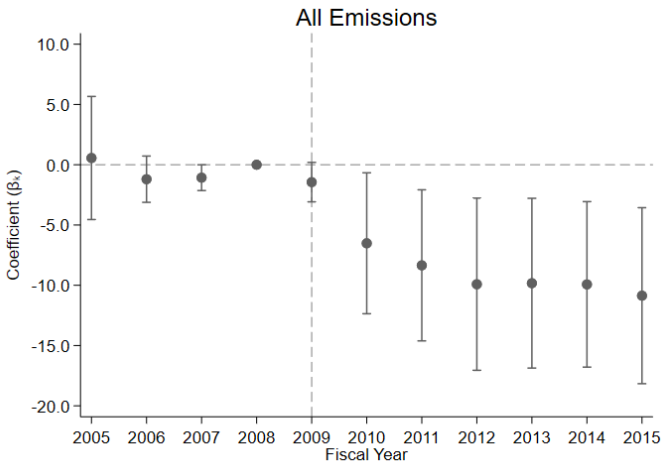
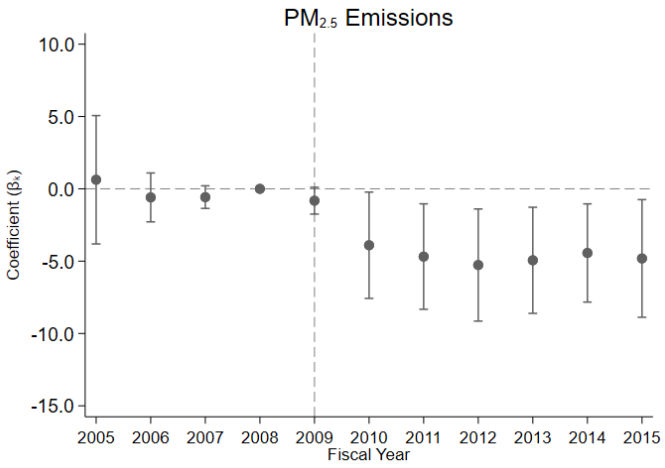


FIGURE 6: BASELINE PRODUCT CHARACTERISTICS PRIOR TO THE INTRODUCTION OF CEPI

This figure presents the average firm-product characteristics from 2008, the year preceding the CEPI regulation, plotted in CEPI bins near the cutoff. The data combines information across the CEPI thresholds of 60 and 70 (represented as zero in the figures). A linear fit is generated separately for each side of 0, with the 95% confidence intervals displayed.



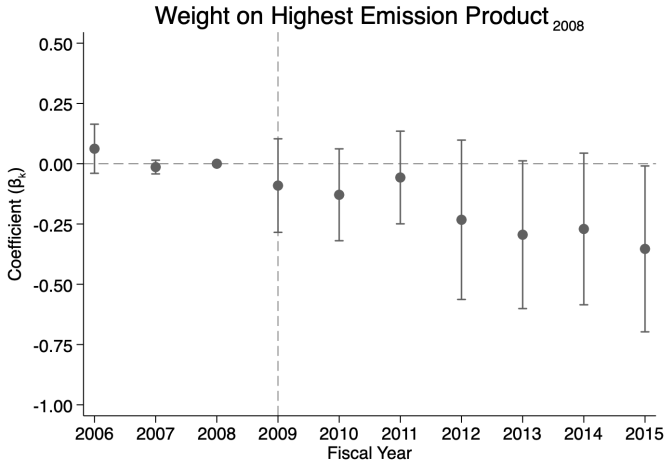
(a) All Pollutants



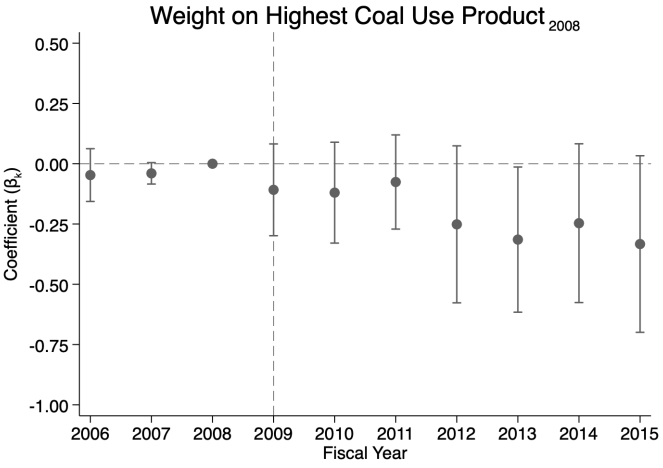
(b) Pollutant: Particulate Matter $< 2.5\mu$

FIGURE 7: CHANGES TO CLUSTER-LEVEL INDUSTRIAL AIR EMISSIONS

This figure presents the dynamic coefficients and their corresponding 95% confidence intervals from a difference-in-differences empirical specification (Equation 2). Panel A incorporates all emissions, while panel B focuses on fine particulate matter less than 2.5 microns. Coefficients are relative to 2008, the year before CEPI regulation, which is normalized to zero. A dotted vertical line indicates the reform. The sample is restricted to the 88 industrial clusters targeted by the CPCB in 2009 with the omitted category including clusters with a CEPI value below 60. Data source: Emissions Database for Global Atmospheric Research (Crippa et al., 2019, 2020; European Commission, Joint Research Centre (EC-JRC)/Netherlands Environmental Assessment Agency (PBL), 2020).



(a) Product with Highest Emissions$_{2008}$



(b) Product with Highest Coal Weight$_{2008}$

FIGURE 8: CHANGES TO PRODUCT PORTFOLIO

This figure presents the dynamic coefficients and their corresponding 95% confidence intervals from a difference-in-differences empirical specification (Equation 2). The dependent variable in panel A is the weight of the highest emission product as of 2008 while in panel G it is the weight of the highest margin product as of 2008. Coefficients are relative to 2008, the year before CEPI regulation, which is normalized to zero. A dotted vertical line indicates the reform. The sample is restricted to the 88 industrial clusters targeted by the CPCB in 2009 with the omitted category including clusters with a CEPI value below 60. Data source: CMIE Prowess.

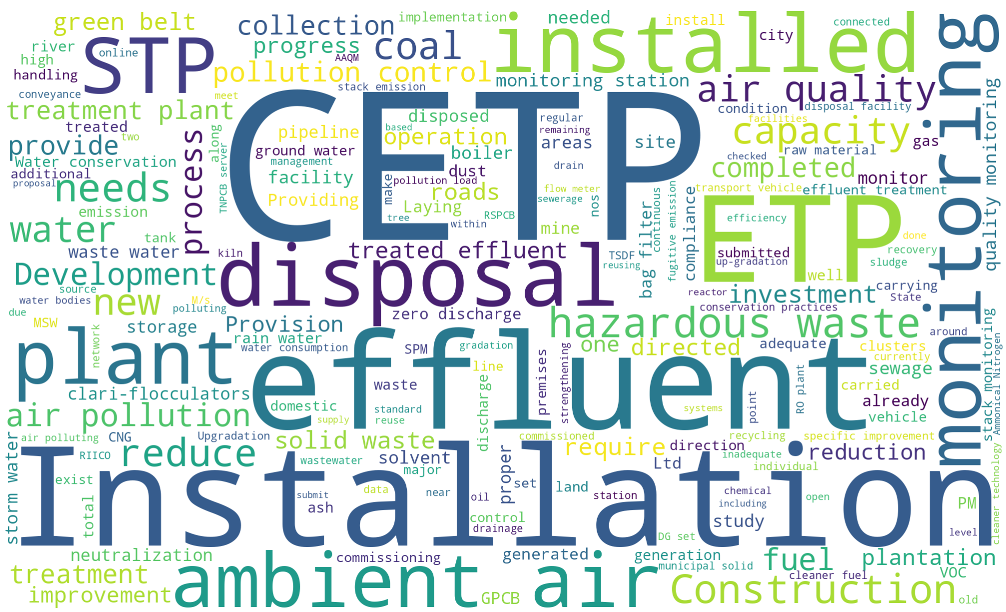


FIGURE 9: TEXTUAL ANALYSIS OF ACTION PLANS

This figure displays a word cloud constructed from the textual descriptions contained in industrial action plans. The visualization is based on processed text data, where the size of each word reflects its frequency within the corpus after standard text cleaning and filtering procedures. The figure provides a descriptive representation of the language used across all plans.

TABLE 1: SUMMARY STATISTICS

This table presents descriptive statistics for the firms and products in our baseline sample. Panel A summarizes the firm-year panel dataset. Panel B summarizes the firm-product-year dataset. All variables are defined in Appendix Table IAB8.

	Panel A: Firm characteristics					
	Obs	Mean	Std. dev.	Min.	Median	Max.
	(1)	(2)	(3)	(4)	(5)	(6)
Assets (000 INR)	11,452	3,524	8,864	6.70	621	52,664
Sales (000 INR)	11,452	3,282	7,274	3.90	755	40,262
Leverage	10,307	0.27	0.20	0.00	0.25	1.13
Exporting Intensity	11,452	16.30	26.09	0.00	1.64	97.84
Ln(Revenue Productivity)	11,452	3.07	1.86	1.02	2.54	8.63
Ln(Quantity Productivity)	2,079	1.36	1.53	-1.75	1.39	4.65
Number Product Lines	11,452	2.84	2.02	1.00	2.00	22.00
Profitability	11,452	0.11	0.08	-0.09	0.10	0.30
Investments/Assets	10,394	0.67	0.41	0.03	0.61	2.42
Abatement Expenditure/Assets	11,452	0.03	0.18	0.00	0.00	2.15
Raw Materials/Sales	11,451	0.58	0.22	0.03	0.60	1.01
Wages/Sales	11,451	0.05	0.05	0.00	0.04	0.30
Market-to-book	1,949	0.88	1.23	0.02	0.41	6.86
	Panel B: Firm-product characteristics					
	Obs	Mean	Std. dev.	Min.	Median	Max.
	(1)	(2)	(3)	(4)	(5)	(6)
Ln(Product Sales)	30,143	4.44	2.78	-2.30	4.76	9.63
Ln(Unit Cost)	15,589	-4.97	3.86	-15.35	-3.85	3.44
Ln(Unit Price)	16,329	-4.92	3.87	-15.24	-3.73	3.37
Margin (%)	15,589	0.01	0.70	-5.67	0.14	0.64
Ln(Per Unit CO_2 Emissions)	1,163	-2.35	2.80	-9.83	-1.85	2.42
Ln(Value Energy Input)	1,163	13.81	2.96	5.29	14.39	21.48
$\mathbb{1}_{\text{Coal Use}}$	1,163	0.25	0.43	0.00	0.00	1
Coal's Proportion of Inputs	1,163	0.59	0.46	0.00	1.00	1.00

TABLE 2: COVARIATE BALANCE

This table presents tests for differences in firm and product characteristics before the 2009 reform for the regression sample. Panel A reports balance at the firm level while Panel B reports balance at the firm-product level. In both panels, Column 1 present the unconditional mean for the whole sample while Columns 2 and 3 present the unconditional means for cities below the treatment threshold and cities above the treatment threshold, respectively. Column 4 presents the difference in means between cities below the treatment threshold and cities above the treatment threshold. Column 5 shows the regression discontinuity estimate of the effect of being above the treatment threshold on the baseline variable. The model is estimated within a bandwidth of 10 units of the CEPI around the treatment thresholds at 60 and 70, and accounts for difference across states and within industries. Finally, Column 6 is the p-value for this estimate, using bias-corrected, heteroskedasticity-robust standard errors of Calonico, Cattaneo, and Farrell (2020). All variables are defined in Appendix Table IAB8.

	Panel A: Firm characteristics					
	All	Below	Above	Difference	RD Estimate	p-value
	(1)	(2)	(3)	(4)	(5)	(6)
Assets (000 INR)	2,500	2,127	2,566	-439	-1,317	0.68
Sales (000 INR)	2,418	1,853	2,519	-665	-348	0.90
Leverage	0.27	0.29	0.27	0.02	-0.041	0.39
Exporting Intensity	0.25	0.23	0.25	-0.022	0.095	0.17
Ln(Revenue Productivity)	3.30	3.30	3.30	-0.0028	-0.18	0.72
Ln(Quantity Productivity)	1.50	1.70	1.50	0.20	-0.82	0.46
Number Product Lines	2.9	2.90	2.90	-0.035	0.35	0.35
Profitability	0.11	0.11	0.12	-0.0064	0.023	0.16
Investments/Assets	0.70	0.77	0.69	0.083	-0.16	0.14
Abatement Expenditure/Asset	0.02	0.01	0.02	-0.01	0.03	0.11
Raw Materials/Sales	0.57	0.60	0.57	0.037	0.0006	0.99
Wages/Sales	0.06	0.06	0.07	-0.01	0.03	0.15
Market-to-book	1.10	0.95	1.10	-0.14	0.81	0.35
	Panel B: Firm-product characteristics					
	All	Below	Above	Difference	RD Estimate	p-value
	(1)	(2)	(3)	(4)	(5)	(6)
Ln(Product Sales)	4.10	3.80	4.10	-0.30	-0.48	0.47
Ln(Unit Cost)	-5.00	-4.70	-5.00	0.33	-0.37	0.52
Ln(Unit Price)	-5.00	-4.70	-5.00	0.36	-0.26	0.59
Margin(%)	-2.30	-1.50	-2.50	1.00	-4.50	0.57
Ln(Unit CO2 Emissions)	-2.50	-2.20	-2.50	0.36	-0.85	0.27
Ln(Value Energy Input)	13.69	13.83	13.66	0.17	-0.65	0.31
$\mathbb{1}_{\text{Coal Use}}$	0.22	0.18	0.23	-0.05	0.08	0.53
Coal's Proportion of Inputs	0.65	0.66	0.65	0.01	0.35	0.09

TABLE 3: CHANGES IN CLUSTER INDUSTRIAL EMISSIONS BY POLLUTANT

This table reports the impact of the 2009 CEPI emissions regulation on industrial emissions. The unit of analysis is at the cluster-year-month level. The dependent variable is the measurement of emissions within a 5 kilometer radius circle around the centroid of the industrial cluster. In column 1, we focus on all pollutants whereas subsequent columns break each out separately: $PM_{2.5}$ (column 2), PM_{10} (column 3) and NO_x (column 4). $CEPI^{[70,100]}$ takes the value of one if the industrial cluster has a CEPI value at or above 70, and zero otherwise. $CEPI^{[60,70)}$ takes the value of one if the industrial cluster has a CEPI value greater than or equal to 60 and below 70, and zero otherwise. The sample is restricted to the 88 industrial clusters targeted by the CPCB in 2009 with the omitted category including clusters with a CEPI value below 60. All specifications include cluster-address fixed effects and state × year-month fixed effects. The table also reports the *p*-value from the joint test of the coefficients as well as the mean of the dependent variable in levels in the pre-reform year of 2008. The standard errors are clustered at the cluster-address level and are robust to heteroscedasticity. ***, **, * denote significance at the 1%, 5%, and 10% level, respectively. All variables are defined in Appendix Table IAB8. Data: The Emissions Database for Global Atmospheric Research (EDGAR).

Dependent variable:	Pollution Measurement (mg per month)			
Pollutant(s):	All	$PM_{2.5}$	PM_{10}	NO_x
	(1)	(2)	(3)	(4)
Post ×CEPI$^{[60,70)}$ (β_1)	-7.232**	-3.686*	-7.113	-10.898*
	(3.597)	(2.054)	(5.653)	(6.536)
Post ×CEPI$^{[70,100]}$ (β_2)	-7.109**	-3.489*	-7.669	-10.169*
	(3.225)	(1.813)	(4.748)	(5.937)
2008 Dependent Variable Mean (Control)	23.09	16.86	38.95	13.45
Fixed effects:				
Cluster × Pollutant	Yes	Yes	Yes	Yes
State × year-month × Pollutant	Yes	Yes	Yes	Yes
Adjusted-R^2	0.932	0.949	0.946	0.836
Observations	54,648	18,216	18,216	18,216
p-value [$\beta_1 - \beta_2 = 0$]	0.935	0.843	0.840	0.600
ATE	-7.144	-3.545	-7.512	-10.375
t-statistic value	[2.185]	[1.928]	[1.550]	[1.702]

TABLE 4: IMPACT ON PRODUCT EMISSIONS

This table reports the changes in product emissions around the 2009 CEPI emissions regulation. The unit of analysis is firm-product-year. The dependent variables are: Product-level emissions (column 1) and Product-level emissions scaled by production quantity (column 2). *Post* is an indicator variable taking the value of 1 for all years including 2009 the year in which reform was implemented and after. $CEPI^{[60,70)}$ takes the value of one if the industrial cluster has a CEPI value greater than or equal to 60 and below 70, and zero otherwise. $CEPI^{[70,100]}$ takes the value of one if the industrial cluster has a CEPI value at or above 70, and zero otherwise. The sample is restricted to the 88 industrial clusters targeted by the CPCB in 2009 with the omitted category including clusters with a CEPI value below 60. All specifications include firm and State × two-digit industry × year fixed effects. The table also reports the *p*-value from the joint test of the coefficients and the mean of the dependent variable in levels in the pre-reform year 2008. The standard errors are clustered at the city level and are robust to heteroscedasticity. ***, **, * denote significance at the 1%, 5%, and 10% level, respectively. All variables are defined in Appendix Table IAB8. Data source: CMIE Prowess.

Dependent variable:	Ln(Product CO_2 Emissions) (1)	Ln(Per Unit CO_2 Emissions) (2)
Post $\times CEPI^{[60,70)}$ (β_1)	-0.695**	-0.544*
	(0.299)	(0.272)
Post $\times CEPI^{[70,100]}$ (β_2)	-0.598**	-0.436*
	(0.290)	(0.245)
Ln(Quantity Produced)	0.922***	
	(0.215)	
2008 Dependent Variable Mean (Control)	162229.58	2.79
Fixed effects:		
Firm	Yes	Yes
State × Industry × Year	Yes	Yes
Adjusted-R^2	0.840	0.713
Observations	1,423	1,423
p-value $[\beta_1 - \beta_2 = 0]$	0.740	0.702
ATE	-0.638	-0.480
t-statistic value	[2.614]	[2.403]

TABLE 5: IMPACT ON ENERGY EFFICIENCY AND INPUTS

This table reports the changes in firm energy use (panel A) and energy inputs (panel B) around the 2009 CEPI emissions regulation. In panel A, the dependent variable in column 1 is the natural logarithm of the quantity of each product produced by the firm in the year, controlling for cost-per-unit. In column 2, it is the natural logarithm of the input energy value at the firm-year level, controlling for the natural logarithm of cost of goods sold. In panel B, the dependent variable in column 1, is an indicator variable for if the firm-product uses coal as an input. In column 2, it is the proportion of electricity purchased for each product. $\text{CEPI}^{[70,100]}$ is an indicator variable for if the industrial cluster has a CEPI value at or above $\text{CEPI}^{[60,70)}$ is an indicator variable for if the industrial cluster has a CEPI value greater than or equal to 60 and below 70. The sample is restricted to the 88 industrial clusters targeted by the CPCB in 2009 with the omitted category as clusters with a CEPI value below 60. All specifications include firm and state $\times$ two-digit industry $\times$ year fixed effects. The table also reports the p-value from the joint test of the coefficients as well as the mean of the dependent variable in levels in the pre-reform year of 2008. The standard errors are clustered at the city level and are robust to heteroscedasticity. ***, **, * denote significance at the 1%, 5%, and 10% level, respectively. Data source: CMIE Prowess.

	Panel A: Energy Use	
Dependent variable	Ln(Quantity Produced)	Ln(Value Energy Input)
	(1)	(2)
Post $\times\text{CEPI}^{[60,70)}$ (β_1)	-0.090	-0.244***
	(0.108)	(0.068)
Post $\times\text{CEPI}^{[70,100]}$ (β_2)	-0.042	-0.156**
	(0.095)	(0.061)
2008 Dependent Variable Mean (Control)	29783.99	813.22
Fixed effects:		
Firm $\times$ Product	Yes	Yes
State $\times$ Industry $\times$ Year	Yes	Yes
Adjusted-R^2	0.926	0.952
Observations	23,834	10,732
p-value $[\beta_1 - \beta_2 = 0]$	0.606	0.028
ATE	-0.051	-0.172
t-statistic value	[0.575]	[2.828]
	Panel B: Energy Inputs	
Dependent variable	$\mathbb{1}_{\text{Coal Use}}$	Proportion Purchased Electricity
	(1)	(2)
Post $\times\text{CEPI}^{[60,70)}$ (β_1)	-0.147	0.038**
	(0.098)	(0.017)
Post $\times\text{CEPI}^{[70,100]}$ (β_2)	-0.189***	0.041***
	(0.059)	(0.015)
2008 Dependent Variable Mean (Control)	0.17	0.46
Fixed effects:		
Firm $\times$ Product	Yes	Yes
State $\times$ Industry $\times$ Year	Yes	Yes
Adjusted-R^2	0.162	0.858
Observations	823	1,411
p-value $[\beta_1 - \beta_2 = 0]$	0.623	0.865
ATE	-0.176	0.040
t-statistic value	[2.581]	[3.022]

TABLE 6: IMPACT ON FIRM PORTFOLIO WEIGHTS

This table reports the changes to firm product portfolios around the 2009 CEPI emissions regulation. The unit of analysis is firm-year. The dependent variable in column 1 is the firm-level weight on the highest emission product in the firm's overall product portfolio, measured in percentage points. For column 2, it is the weight of the product that uses the highest proportion of coal in its energy input mix in the firm's overall product portfolio. *Post* is an indicator variable taking the value of one for all years from 2009, the year in which reform was implemented, and zero otherwise. $CEPI^{[70,100]}$ takes the value of one if the industrial cluster has a CEPI value at or above 70, and zero otherwise. $CEPI^{[60,70)}$ takes the value of one if the industrial cluster has a CEPI value greater than or equal to 60 and below 70, and zero otherwise. The sample is restricted to the 88 industrial clusters targeted by the CPCB in 2009 with the omitted category comprising clusters with a CEPI value below 60. The table also reports the *p*-value from the joint test of the coefficients as well as the mean of the dependent variable in levels in the pre-reform year 2008. All specifications include firm and State × two-digit industry × year fixed effects. The standard errors are clustered at the city level and are robust to heteroscedasticity. ***, **, * denote significance at the 1%, 5%, and 10% level, respectively. All variables are defined in Appendix Table IAB8. Data source: CMIE Prowess.

Dependent variable:	Product with Highest Emissions Weight$_{2008}$ (1)	Product with Highest Coal Weight$_{2008}$ (2)
Post ×CEPI$^{[60,70)}$ (β_1)	-0.159*	-0.162*
	(0.089)	(0.092)
Post ×CEPI$^{[70,100]}$ (β_2)	-0.055	-0.010
	(0.069)	(0.073)
2008 Dependent Variable Mean (Control)	0.65	0.82
Fixed effects:		
Firm × Product	Yes	Yes
State × Industry × Year	Yes	Yes
Adjusted-R^2	0.903	0.916
Observations	2,541	2,541
p-value [$\beta_1 - \beta_2 = 0$]	0.092	0.031
ATE	-0.087	-0.056
t-statistic value	[0.963]	[0.547]

TABLE 7: IMPACT ON ABATEMENT EXPENDITURES

This table reports the changes in firm abatement expenditure around the 2009 CEPI emissions regulation. The unit of analysis is firm-year. The dependent variable in column 1 captures the extensive margin of investment with an indicator variable that takes the value one if the firm report environment and pollution control expenses in that year, and zero otherwise. In column 2 captures the intensive margin, defined as the ratio of expenses and total assets, winsorized at 1% tails. *Post* is an indicator variable taking the value of one for all years from 2009, the year in which reform was implemented, and zero otherwise. $\text{CEPI}^{[70,100]}$ takes the value of one if the industrial cluster has a CEPI value at or above 70, and zero otherwise. $\text{CEPI}^{[60,70)}$ takes the value of one if the industrial cluster has a CEPI value greater than or equal to 60 and below 70, and zero otherwise. The sample is restricted to the 88 industrial clusters targeted by the CPCB in 2009 with the omitted category including clusters with a CEPI value below 60. The table also reports the *p*-value from the joint test of the coefficients as well as the mean of the dependent variable in levels in the pre-reform year 2008. All specifications include firm and state × two-digit industry × year fixed effects. The standard errors are clustered at the city level and are robust to heteroscedasticity. ***, **, * denote significance at the 1%, 5%, and 10% level, respectively. All variables are defined in Appendix Table IAB8. Data source: CMIE Prowess.

	Panel A: Average effect	
Dependent variable:	$\mathbb{1}_{\text{Abatement}}$	Abatement/Assets
	(1)	(2)
Post ×$\text{CEPI}^{[60,70)}$ (β_1)	0.048	0.039*
	(0.031)	(0.020)
Post ×$\text{CEPI}^{[70,100]}$ (β_2)	0.077**	0.038**
	(0.029)	(0.016)
2008 Dependent Variable Mean (Control)	0.06	0.01
Fixed effects:		
Firm	Yes	Yes
State × Industry × Year	Yes	Yes
Adjusted-R^2	0.638	0.676
Observations	10,752	10,752
p-value [$\beta_1 - \beta_2 = 0$]	0.029	0.933
ATE	0.072	0.038
t-statistic value	[2.419]	[2.385]

	Panel B: Heterogeneity by firm size	
Dependent variable:	$\mathbb{1}_{\text{Abatement}}$	Abatement/Assets
	(1)	(2)
Post ×$\text{CEPI}^{[60,70)}$ (β_1)	0.039	0.056*
	(0.063)	(0.032)
Post ×$\text{CEPI}^{[70,100]}$ (β_2)	0.112*	0.066**
	(0.061)	(0.031)
Post ×$\text{CEPI}^{[60,70)}$ × Small (β_3)	0.032	0.017
	(0.028)	(0.017)
Post ×$\text{CEPI}^{[70,100]}$ × Small (β_4)	0.041**	0.010
	(0.020)	(0.010)
2008 Dependent Variable Mean (Control)	0.06	0.01
Fixed effects:		
Firm	Yes	Yes
State × Industry × Year	Yes	Yes
Adjusted-R^2	0.639	0.676
Observations	10,752	10,752

TABLE 8: IMPACT ON PRODUCT PORTFOLIO

This table reports the changes to firm product portfolios around the 2009 CEPI emissions regulation. The unit of analysis is firm-year. The dependent variable in column 1 is the natural logarithm of the total quantity produced for each product in a year. In column 2 it is the natural logarithm of the total number of products produced by a firm in a year. In column 3 it is an indicator for whether the firm added a product in a year. And in column 4 it is an indicator for whether the firm dropped a product in that year. *Post* is an indicator variable for all years from 2009, the year in which reform was implemented. $^{[70,100]}$ is an indicator variable for if the industrial cluster has a CEPI value at or above 70. $^{[60,70)}$ is an indicator variable for if the industrial cluster has a CEPI value greater than or equal to 60 and below 70. The sample is restricted to the 88 industrial clusters targeted by the CPCB in 2009 with the omitted category including clusters with a CEPI value below 60. The table also reports the *p*-value from the joint test of the coefficients as well as the mean of the dependent variable in levels in the pre-reform year 2008. All specifications include firm and sstate × two-digit industry × year fixed effects. The standard errors are clustered at the city level and are robust to heteroscedasticity. ***, **, * denote significance at the 1%, 5%, and 10% level, respectively. All variables are defined in Appendix Table IAB8. Data source: CMIE Prowess.

Dependent variable:	# products	$\mathbb{1}_{\text{Add Product}}$	$\mathbb{1}_{\text{Remove Product}}$
	(1)	(2)	(3)
Post ×CEPI$^{[60,70)}$ (β_1)	0.013	-0.117***	0.003
	(0.078)	(0.041)	(0.036)
Post ×CEPI$^{[70,100]}$ (β_2)	0.007	-0.057*	0.023
	(0.072)	(0.034)	(0.030)
2008 Dependent Variable Mean (Control)	2.71	2.71	2.71
Fixed effects:			
Firm	Yes	Yes	Yes
State × Industry × Year	Yes	Yes	Yes
Adjusted-R^2	0.666	0.032	0.005
Observations	10,752	10,752	10,752
p-value [$\beta_1 - \beta_2 = 0$]	0.904	0.094	0.314
ATE	0.008	-0.068	0.019
t-statistic value	[0.118]	[2.138]	[0.621]

TABLE 9: CHANGES IN CLUSTER-LEVEL FIRM ENTRY

This table reports changes in cluster firm entry around the 2009 CEPI emissions regulation. The unit of analysis is cluster-industry-year. Panel A reports changes in firm entry using the universe of business registration from the Ministry of Corporate Affairs while Panel B reports changes in firm entry from CMIE Prowess. Across both panels, the dependent variable in column 1 is an indicator for whether at least one manufacturing firm incorporates in the cluster in a given industry in the year. In column 2 it is the raw number of newly-registered manufacturing firms in each cluster in a specific industry in that year. $CEPI^{[70,100]}$ is an indicator variable for if the industrial cluster has a CEPI value at or above 70. $CEPI^{[60,70)}$ is an indicator variable for if the industrial cluster has a CEPI value greater than or equal to 60 and below 70. The sample is restricted to the 88 industrial clusters targeted by the CPCB in 2009 with the omitted category as clusters with a CEPI value below 60. The table also reports the *p*-value from the joint test of the coefficients as well as the mean of the dependent variable in levels in the pre-reform year 2008. In both panels, column 1 is estimated using ordinary least squares (OLS) while column 2 is estimated using pseudo-Poisson maximum likelihood (PPML). All specifications include cluster, two-digit industry × year, and state × year fixed effects. The standard errors are clustered at the city level and are robust to heteroscedasticity. ***, **, * denote significance at the 1%, 5%, and 10% level, respectively. All variables are defined in Appendix Table IAB8. Data: Ministry of Corporate Affairs and CMIE Prowess.

	Panel A: All firms from business registry	
Dependent variable:	$\mathbb{1}_{\text{New Firm}}$	No. of firms (Poisson)
	(1)	(2)
Post ×CEPI$^{[60,70)}$ (β_1)	-0.005	-0.154
	(0.011)	(0.129)
Post ×CEPI$^{[70,100]}$ (β_2)	-0.018*	-0.193*
	(0.010)	(0.115)
2008 Dependent Variable Mean (Control)	0.07	0.19
Fixed effects:		
Cluster	Yes	Yes
State × Industry × Year	Yes	Yes
Adjusted-R^2	0.405	
Observations	33,810	20,590
p-value [$\beta_1 - \beta_2 = 0$]	0.101	0.704
ATE	-0.014	-0.177
t-statistic value	[1.396]	[1.602]
	Panel B: Large firms in CMIE Prowess	
Dependent variable:	$\mathbb{1}_{\text{New Firm}}$	No. of firms (Poisson)
	(1)	(2)
Post ×CEPI$^{[60,70)}$ (β_1)	-0.003	-0.289
	(0.017)	(0.440)
Post ×CEPI$^{[70,100]}$ (β_2)	-0.041*	-0.795**
	(0.021)	(0.370)
2008 Dependent Variable Mean (Control)	0.01	0.01
Fixed effects:		
Cluster	Yes	Yes
State × Industry × Year	Yes	Yes
Bandwidth	Yes	Yes
Adjusted-R^2	0.172	
Observations	4,416	678
p-value [$\beta_1 - \beta_2 = 0$]	0.018	0.103
ATE	-0.024	-0.655
t-statistic value	[1.351]	[1.672]

INTERNET APPENDIX FOR ONLINE PUBLICATION

Appendix A Additional figures and tables

TABLE IAA1: SUMMARY STATISTICS BY PRODUCT SECTOR

This table reports summary statistics by two-digit NIC product code in 2008, the year before the CEPI reform. Column (1) reports the share of the output by sector in 2008. Column (2) reports the number of unique product codes within each NIC sector. Data source: CMIE Prowess. Industry Classification: Central Statistical Organization (2008). National Industrial Classification 2008. Ministry of Statistics and Programme Implementation, Government of India.

Manufacturing sector	Share of total output (1)	Unique products (2)
Beverages	0.47	27
Tobacco Products	0.89	24
Textiles	4.80	177
Readymade Garments	1.42	65
Leather Products	0.26	33
Wood Products	0.08	25
Paper Products	1.54	59
Printing and Recording	0.26	15
Coke and Petroleum Products	0.45	27
Chemicals	9.69	312
Pharmaceuticals	6.99	96
Rubber and Plastics	4.94	169
Cement, Ceramics, and Glass	5.83	93
Metals	26.93	201
Tools and Hardware	2.62	119
Computers and Optical Equipment	3.03	145
Electrical Equipment	6.26	205
Machinery	5.55	216
Motor Vehicles and Trailers	9.37	24
Transport Equipment	3.21	143
Furniture	0.00	7
Other Manufacturing	5.40	54
Total	100	2,236

TABLE IAA2: CLUSTER-LEVEL COVARIATE BALANCE

This table presents mean values for baseline city characteristics, as recorded in Population Census. Column 1 presents the unconditional mean while column 2 (column 3) presents the mean for clusters below (above) the treatment threshold. Column 4 presents the difference in means between cities below the treatment threshold and cities above the treatment threshold. Additionally, column 5 shows the regression discontinuity estimate, following the main estimating equation, of the effect of being above the treatment threshold on the baseline variable and column 6 is the *p*-value for this estimate, using heteroskedasticity-robust standard errors. Data: Population Census and Harari (2020).

	All	Below	Above	Difference	Estimate	*p*-value
	(1)	(2)	(3)	(4)	(5)	(6)
City roads, km, 1981	337.206	268.936	391.822	-122.886	-297.226	0.486
Log(population), 2001	13.330	13.015	13.572	-0.556	0.403	0.693
Population density (000 per Sq. km), 2001	8.632	9.387	7.993	1.394	-1.081	0.802
Average rent (per Sq. m.), 2008	953.696	907.779	990.430	-82.651	356.072	0.422
Nearest waterway (km), 2008	13.901	17.660	10.948	6.713	-16.694	0.182
Agricultural yields (tons/ha), 2008	1.440	1.485	1.406	0.079	0.111	0.123
Area footprint (Sq. km.), 2008	187.831	114.277	250.069	-135.792	184.250	0.485

TABLE IAA3: IMPACTS ON FINE PARTICULATE MATTER ($PM_{2.5}$)

This table reports the impact of CEPI reform on fine particulate matter using data from Van Donkelaar, Martin, Spurr, and Burnett (2015). The unit of analysis for Panel (a) is at the cluster-yearmonth level. All specifications include cluster-address fixed effects and State × yearmonth fixed effects. The unit of analysis for Panel (b) is at the firm-yearmonth level. All specifications include firm fixed effects and Industry × State × yearmonth fixed effects. In both panels, *Post* is an indicator variable taking the value of 1 for all years including 2009 the year in which reform was implemented and after. $CEPI^{[70,100]}$ takes the value of one if the industrial cluster has a CEPI value at or above 70, and zero otherwise. $CEPI^{[60,70)}$ takes the value of one if the industrial cluster has a CEPI value greater than or equal to 60 and below 70, and zero otherwise. The sample is restricted to the 88 industrial clusters targeted by the CPCB in 2009 with the omitted category including clusters with a CEPI value below 60. The table also reports the *p*-value from the joint test of the coefficients and the mean of the dependent variable in levels in the pre-reform year of 2008. The standard errors are clustered at the cluster-address level and are robust to heteroscedasticity. ***, **, * denote significance at the 1%, 5%, and 10% level, respectively. All variables are defined in Appendix Table IAB8. Data source: Van Donkelaar, Martin, Spurr, and Burnett (2015).

Dependent variable:	Fine $PM_{2.5}$ (μ g/m^3)	
Radii of circle:	5 kilometers	500 meters
	(1)	(2)
Post ×CEPI$^{[70,100]}$ (β_2)	-2.311***	-1.893**
	(0.775)	(0.743)
Post ×CEPI$^{[60,70)}$ (β_1)	-1.018	-0.560
	(0.756)	(0.673)
2008 Dependent Variable Mean (Control)	84.0	80.7
Fixed effects:		
Cluster	Yes	Yes
State × year-month	Yes	Yes
Bandwidth	Yes	Yes
Adjusted-R^2	0.959	0.954
Observations	17,952	18,216
p-value [$\beta_1 - \beta_2 = 0$]	0.005	0.069
ATE	-1.962	-1.516
t-statistic value	[2.596]	[2.152]

TABLE IAA4: CHANGES IN CLUSTER INDUSTRIAL EMISSIONS BY POLLUTANT

This table reports the impact of the 2009 CEPI emissions regulation on industrial emissions. The unit of analysis is at the cluster-year-month level. The dependent variable is the measurement of emissions within a 5 kilometer radius circle around the centroid of the industrial cluster. In column 1, we focus on all pollutants whereas subsequent columns break each out separately: $PM_{2.5}$ (column 2), PM_{10} (column 3) and NO_x (column 4). *Post* is an indicator variable taking the value of one for all years from 2009, the year in which reform was implemented, and zero otherwise. $CEPI^{[70,100]}$ takes the value of one if the industrial cluster has a CEPI value at or above 70, and zero otherwise. $CEPI^{[60,70)}$ takes the value of one if the industrial cluster has a CEPI value greater than or equal to 60 and below 70, and zero otherwise. The sample is restricted to the 88 industrial clusters targeted by the CPCB in 2009 with the omitted category including clusters with a CEPI value below 60. All specifications include cluster-address fixed effects and state $\times$ year-month fixed effects. The table also reports the *p*-value from the joint test of the coefficients as well as the mean of the dependent variable in levels in the pre-reform year of 2008. The standard errors are clustered at the cluster-address level and are robust to heteroscedasticity. ***, **, * denote significance at the 1%, 5%, and 10% level, respectively. All variables are defined in Appendix Table IAB8. Data source: The Emissions Database for Global Atmospheric Research (EDGAR).

Dependent variable:	Pollution Measurement (mg per month)			
Pollutant(s):	All	$PM_{2.5}$	PM_{10}	NO_x
	(1)	(2)	(3)	(4)
Post $\times CEPI^{[60,70)}$ (β_1)	-0.030	-0.030	-0.031	-0.028
	(0.027)	(0.030)	(0.031)	(0.019)
Post $\times CEPI^{[70,100]}$ (β_2)	-0.008	-0.007	-0.007	-0.010
	(0.025)	(0.028)	(0.030)	(0.019)
2008 Dependent Variable Mean (Control)				
Fixed effects:				
Cluster $\times$ Pollutant	Yes	Yes	Yes	Yes
State $\times$ year-month $\times$ Pollutant	Yes	Yes	Yes	Yes
Adjusted-R^2	0.83	0.82	0.82	0.82
Observations	90036	30012	30012	30012
p-value $[\beta_1 - \beta_2 = 0]$	0.263	0.318	0.313	0.131
ATE	-0.016	-0.016	-0.017	-0.017
t- statistic value	[0.679]	[0.591]	[0.588]	[0.939]

TABLE IAA5: IMPACT ON FIRM FACTORS OF PRODUCTION

This table reports the effect of the 2009 CEPI regulation on firm factors of production. All specifications impose a bandwidth of 10 CEPI units around the cutoffs at 70 and 60 and firm and state × year and NIC2 × year fixed effects, where NIC2 is the product code of the firm's main product, defined based on sales. The standard errors are clustered at the city level and are robust to heteroscedasticity. ***, **, * denote significance at the 1%, 5%, and 10% level, respectively. Data source: PROWESS.

Dependent variable	Wages/Lagged Sales (1)	Material Expense/ Lagged Sales (2)	CAPX/Lagged Assets (3)
Post $\times$CEPI$^{[70,100]}$ (β_1)	-0.004	0.031	0.032
	(0.010)	(0.028)	(0.026)
Post $\times$CEPI$^{[60,70)}$ (β_2)	-0.006	0.021	-0.008
	(0.010)	(0.032)	(0.030)
p-value [$\beta_1 + \beta_2 = 0$]	0.635	0.370	0.650
2008 Control Mean	0.057	0.524	-0.126
Fixed effects:			
Firm	Yes	Yes	Yes
State $\times$ year & NIC2 $\times$ year	Yes	Yes	Yes
Bandwidth	Yes	Yes	Yes
Adjusted-R^2	0.320	0.609	0.800
Observations	5,562	5,562	4,670

Appendix B Emissions Shifting

TABLE IAB6: SHIFTING PRODUCTION: IMPACT ON MERGERS AND ACQUISITIONS

This table reports changes in mergers and acquisitions around the 2009 CEPI emissions regulation. The unit of analysis is firm-year. $CEPI^{[70,100]}$ is an indicator variable for if the industrial cluster has a CEPI value at or above 70. $CEPI^{[60,70)}$ is an indicator variable for if the industrial cluster has a CEPI value greater than or equal to 60 and below 70. The sample is restricted to the 88 industrial clusters targeted by the CPCB in 2009 with the omitted category as clusters with a CEPI value below 60. The table also reports the p-value from the joint test of the coefficients as well as the mean of the dependent variable in levels in the pre-reform year 2008. All specifications include firm and state × two-digit industry × year fixed effects. The standard errors are clustered at the city level and are robust to heteroscedasticity. ***, **, * denote significance at the 1%, 5%, and 10% level, respectively. All variables are defined in Appendix Table IAB8. Data: CMIE Prowess.

Dependent variable:	$\mathbb{1}_{\text{Target}}$	$\mathbb{1}_{\text{Acquired}}$
	(1)	(2)
Post ×CEPI$^{[60,70)}$ (β_1)	0.018	-0.000
	(0.012)	(0.008)
Post ×CEPI$^{[70,100]}$ (β_2)	0.009	0.005
	(0.009)	(0.007)
2008 Dependent Variable Mean (Control)	0.00	0.00
Fixed effects:		
Firm	Yes	Yes
State × Industry × Year	Yes	Yes
Adjusted-R^2	-0.060	-0.118
Observations	10,752	10,752
p-value [$\beta_1 - \beta_2 = 0$]	0.345	0.430
ATE	0.007	0.003
t-statistic value	[0.740]	[0.534]

TABLE IAB7: SHIFTING PRODUCTION: PLANT ANNOUNCEMENTS

This table reports changes in the probabilities of plant announcements around the 2009 CEPI emissions regulation. The unit of analysis is firm-year. $CEPI^{[70,100]}$ is an indicator variable for if the industrial cluster has a CEPI value at or above 70. $CEPI^{[60,70)}$ is an indicator variable for if the industrial cluster has a CEPI value greater than or equal to 60 and below 70 The sample is restricted to the 88 industrial clusters targeted by the CPCB in 2009 with the omitted category as clusters with a CEPI value below 60. The table also reports the p-value from the joint test of the coefficients as well as the mean of the dependent variable in levels in the pre-reform year 2008. All specifications include firm and state × two-digit industry × year fixed effects. The standard errors are clustered at the city level and are robust to heteroscedasticity. ***, **, * denote significance at the 1%, 5%, and 10% level, respectively. All variables are defined in Appendix Table IAB8. Data: CMIE Prowess and CapEx.

Dependent variable:	$\mathbb{1}_{\text{New Plant}}$	$\mathbb{1}_{\text{Abandon Plant}}$
	(1)	(2)
Post ×CEPI$^{[60,70)}$ (β_2)	0.008	0.003
	(0.013)	(0.011)
Post ×CEPI$^{[70,100]}$ (β_1)	-0.010	-0.004
	(0.011)	(0.010)
2008 Dependent Variable Mean (Control)	0.00	0.00
Fixed effects:		
Firm	Yes	Yes
State × industry × year	Yes	Yes
Adjusted-R^2	0.350	0.284
Observations	10,752	10,752

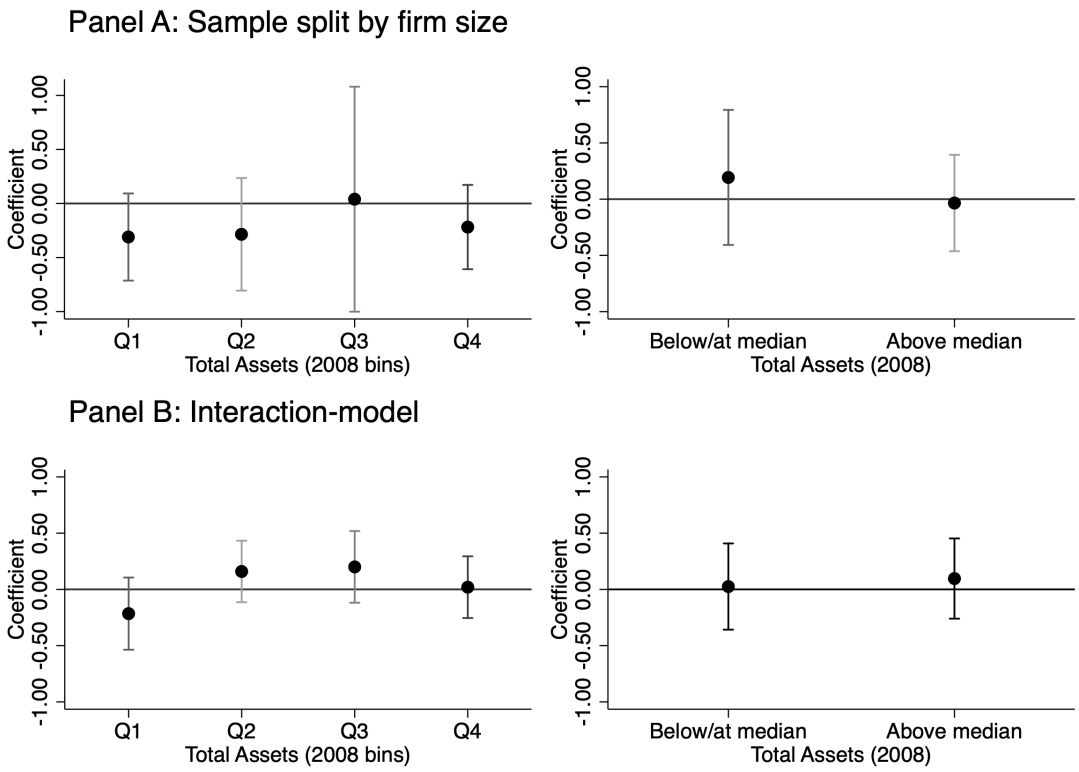


FIGURE IAB1: PRODUCTION RESPONSE BY PRE-REFORM FIRM SIZE

The figure reports treatment effects of the 2009 CEPI reform on ln(product-level production) by 2008 firm size, proxied by total assets. Panel A estimates the model separately within size bins. Panel B estimates a single interaction specification in which the treatment slope varies by bin while other slopes are common. In each panel, the left figure estimates by quartiles while the right by the median of firm size. Points are coefficients; bars are 95% confidence intervals. Specifications use the regression sample of multi-product manufacturing firms in CEPI clusters and include firm×product and state×NIC2-industry×year fixed effects. The standard errors are clustered at the city level and are robust to heteroscedasticity.

TABLE IAB8: VARIABLE DEFINITIONS

This table presents definitions to variables used in the paper. EDGAR refers to the 'Emissions Database for Global Atmospheric Research' data, available at https://edgar.jrc.ec.europa.eu/dataset_htap_v3. PROWESS refers to the 'Performance and Ownership with Excellence' available at https://prowessdx.cmie.com/. CBCB refers to the 'Central Pollution Control Board', with supporting data available at https://cpcb.nic.in/. Note, all normalized variables at the firm-level are winsorized at the 1% tails, except for leverage, productivity, and profitability which are winsorized at the 5% tails. All product-level variables are winsorized at the 1% tails except for emissions, which is winsorized at the 2.5% tails.

Variable	Description	Data Source
Panel A: Pollution		
All Pollution	Summation of pollution measures for a given area	EDGAR
$PM_{2.5}$	Particulate Matter with a diameter of 2.5 micrometers or less, measured in Mg/month	EDGAR
PM_{10}	Particulate Matter with a diameter of 10 micrometers or less, measured in Mg/month	EDGAR
NO_x	Nitrous oxides, measured in Mg/month	EDGAR
$PM_{2.5}$	Fine Particulate Matter with a diameter of 2.5 micrometers or less, measured in Mg/month	Van Donkelaar et al. (2015)
Panel B: Firm Characteristics		
Assets (million INR)	Total assets of firm operations in INR	PROWESS
Sales (million INR)	Total revenue from goods and services sold in missions of INR	PROWESS
Leverage	The sum of short- and long-term debt obligations scaled by contemporaneously reported Total Assets.	PROWESS
Exporting intensity	Firm earnings from exports of goods plus services scaled by contemporaneous total sales	PROWESS
Ln(Productivity)	The natural log of firm productivity, calculated following Levinsohn and Petrin (2003) and controls for firm size	PROWESS
Profitability	Earnings Before Interest, Taxes, Depreciation, and Amortization as a ratio of the prior year sales	PROWESS
Investments/Assets	Gross fixed assets as a ratio of the prior year total assets	PROWESS
Raw Materials/Sales	Raw material inputs scaled by contemporaneously reported net sales	PROWESS
Wages/Sales	Total wages scaled by contemporaneously reported net sales	PROWESS
Market-to-book	The total number of listed shares multiplied by the share price at the end of the fiscal year, scaled by contemporaneously reported total assets. Reported for listed firms	PROWESS
Number of Products	Number of unique products for a given firm in a given year	PROWESS
$\mathbb{1}_{\text{File Energy Inputs}}$	Indicator for whether the firm reports inputs	PROWESS
$\mathbb{1}_{\text{New Plant}}$	Indicator for whether the firm announced a new plant in the year	CapEx
$\mathbb{1}_{\text{Abandon Plant}}$	Indicator for whether the firm announced that it abandoned the plant in the year	CapEx
Panel C: Product Characteristics		
Ln(Product Sales)	The natural logarithm of the per-product sales	PROWESS
Ln(Product COGS)	The natural logarithm of the per-product cost of goods sold (COGS)	PROWESS
Unit Price	The natural logarithm of the per-unit price, where unit is unique within but not across firm	PROWESS
Margin	Is measured as (unit price - unit cost)/unit price	PROWESS
Ln(Per Unit CO_2 Emissions)	Author-calculated CO_2 emissions per reported unit of production	PROWESS
TFPQ	Natural logarithm of quantity-based total factor productivity estimated following De Loecker, Goldberg, Khandelwal, and Pavcnik (2016)	PROWESS
TFPR	Natural logarithm of total factor productivity estimated following Levinsohn and Petrin (2003) that controls for firm size	PROWESS
Panel D: Cluster Characteristics		
$CEPI^{[70,100]}$	CEPI equal or greater than 70, and less or equal to 100	PROWESS and CPCB
$CEPI^{[60,70)}$	CEPI equal or greater than 60, and less than 70	PROWESS and CPCB

Appendix C Additional background on the regulation

By 2009, India was an acknowledged industrial powerhouse. However, significant environmental degradation accompanied impressive growth. This pollution concentrated in industrial clusters, which shared infrastructure, administrative structures, and proximity to major population centers made desirable locations for manufacturing and industrial production. State authorities have regulated industrial cluster emissions since environmental regulation began in the 1980s. However, enforcement has been uneven, emissions measurements and regulatory thresholds were not standardized, and firms were often allowed to self-monitor, rather than be subjected to independent auditors. Moreover, the government lacked even basic information on industrial environmental impact for most locations.

Against this backdrop, the Central Pollution Control Board (CPCB) conducted a comprehensive environmental assessment of industrial clusters. The first step was to design a measure of pollution: The Comprehensive Environmental Pollution Index (CEPI). Figure 1 describes its construction. The CEPI combines proxies for (1) the amount and toxicity of pollutants, (2) the potential impact of that pollution on humans and ecosystems, and (3) an assessment of the quality of actions already taken by cluster firms to capture or adequately dispose of emissions. We include a complete discussion of each component and its construction.

A total of 88 industrial clusters were selected by the CPCB in consultation with the Ministry of Environment & Forests Government of India (MOEFCC) for the study. The CPCB classified those clusters with a CEPI value above 60 as Severely Polluted Areas (SPA). These became subject to central monitoring at the national level rather than the relatively weak local control. Further, the CPCB classified industrial clusters with a CEPI value of at least 70 as Critically Polluted Areas (CPA), which were additionally mandated to submit a remedial action plan for approval detailing the actions and timelines at the cluster and firm levels.

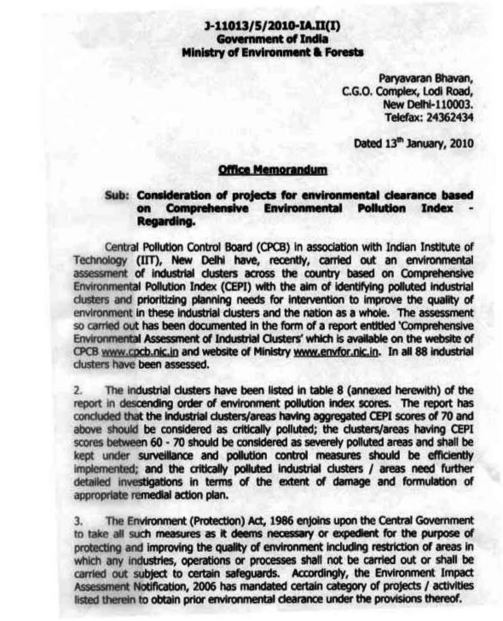
Based on CEPI, MoEF&CC, Govt. of India imposed temporary moratorium on consideration of new projects /expansion of existing projects for environmental clearance to be located in 43 Critically Polluted Areas, vide Office Memorandum, dated 13.01.2010. The progress made in the implementation of these action plans were periodically reviewed by the Local Committees and it is noted that the effective implementation of these action plans helped in the restoration of environmental quality of these 43 areas. MoEF&CC lifted the moratorium from 26 Critically Polluted Areas, vide their O.Ms., dated 26.10.2010, 15.02.2011, 31.03.11, 23.05.2011, & 05.07.11 respectively, however, in respect of the remaining 17 CPAs, moratorium was continued till further orders.

If a firm within a Critically Polluted Area failed to comply with the directives of the action plan, then they would lose their Environmental Clearance and Consent to Operate permits that allow firms to function within the formal economy. Moreover, Consent to Establish permits could not be issued to new operations if they do not fully comply with the cluster regulations and action plans.

Consider the example of the action plan for the CPA Patancheru-Bollaram Cluster in Andhra Pradesh (Pollution Control Board of Andhra Pradesh, 2010), which contains the operations of 106 establishments and whose CEPI, at 70.07, was just over the cutoff between being classified as a Severely or Critically Polluted Area. The Action Plan specifies a lengthy list of specific actions and deadlines agreed to by the firms of the cluster. For example, the cluster agreed to build a common effluent treatment plant, a treatment storage and disposal facility, and alternative drainage systems so no firm would outlet emissions into significant water bodies. In addition, firms operating in specific high-polluting industries would no longer be allowed to expand, and new firms in these industries could not be established in the cluster. The plan also listed self-policing mechanisms the cluster agreed to in order to prevent illegal dumping. In addition, the cluster agreed to pay compensation to local farmers affected by pollution and to supply drinking water to affected villages. The action plan then details a long list of agreed investments and recorded progress for each of the 106 individual establishments in the cluster.

The CPCB also installed continuous remote pollution sensors for air, water, and land pollution, video cameras (including night cameras) on the premises of factories at the point of their process emissions, and instigated tri-annual CPCB audits (January-February, May-June, and September-October) and quarterly audits from district and state level monitoring committees. These reports were released to the public annually via the CPCB website. Each report specifies the longitude and latitude of the air and water sampling locations, the laboratories used to carry out sampling and analyze the samples, and the date of the sampling. Then for each of air, groundwater and surface water samples the report specifies a particular pollutant (e.g., lead) or parameter (e.g., color (Hazen units)), the measurements of that pollutant and the test method used. Finally, the report includes photographs of the measurements. To give readers an idea, Figure IAC4 provides an example of the monitoring documentation for the Patancheru-Bollaram Cluster in Andhra Pradesh. Panel (a) reports the locations of water sampling locations superimposed over a map of the cluster. Panel (b) reproduces a few of the sampling documentation photographs of air, surface and groundwater sampling in the Patancheru-Bollaram Cluster.

Finally, we complement the analysis presented in Figure 3 testing for manipulation of the original, 2009 CEPI with complementary McCrary (2008) density tests for the re-calculated CEPI values in 2011 and 2013. Note that in 2011 and 2013 only the CEPI values for those firms that had been ranked CPA in 2009 were published, so we are testing for manipulation in these updated values among the 2009 CPA sub-population. In summary, in India, as elsewhere,



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Government of India
Ministry of Environment & Forests

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Dated 13th January, 2010

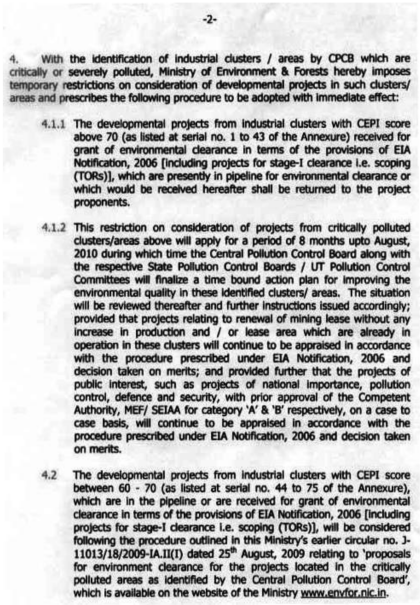
Office Memorandum

Sub: Consideration of projects for environmental clearance based on Comprehensive Environmental Pollution Index - Regarding.

Central Pollution Control Board (CPCB) in association with Indian Institute of Technology (IIT), New Delhi have, recently, carried out an environmental assessment of industrial clusters across the country based on Comprehensive Environmental Pollution Index (CEPI) with the aim of identifying polluted industrial clusters and prioritizing planning needs for intervention to improve the quality of environment in these industrial clusters and the nation as a whole. The assessment so carried out has been documented in the form of a report entitled 'Comprehensive Environmental Assessment of Industrial Clusters' which is available on the website of CPCB www.cpcb.nic.in and website of Ministry www.envfor.nic.in. In all 88 industrial clusters have been assessed.

2. The industrial clusters have been listed in table 8 (annexed herewith) of the report in descending order of environment pollution index scores. The report has concluded that the industrial clusters/areas having aggregated CEPI scores of 70 and above should be considered as critically polluted; the clusters/areas having CEPI scores between 60 - 70 should be considered as severely polluted areas and shall be kept under surveillance and pollution control measures should be efficiently implemented; and the critically polluted industrial clusters / areas need further detailed investigations in terms of the extent of damage and formulation of appropriate remedial action plan.

3. The Environment (Protection) Act, 1986 enjoins upon the Central Government to take all such measures as it deems necessary or expedient for the purpose of protecting and improving the quality of environment including restriction of areas in which any industries, operations or processes shall not be carried out or shall be carried out subject to certain safeguards. Accordingly, the Environment Impact Assessment Notification, 2006 has mandated certain category of projects / activities listed therein to obtain prior environmental clearance under the provisions thereof.



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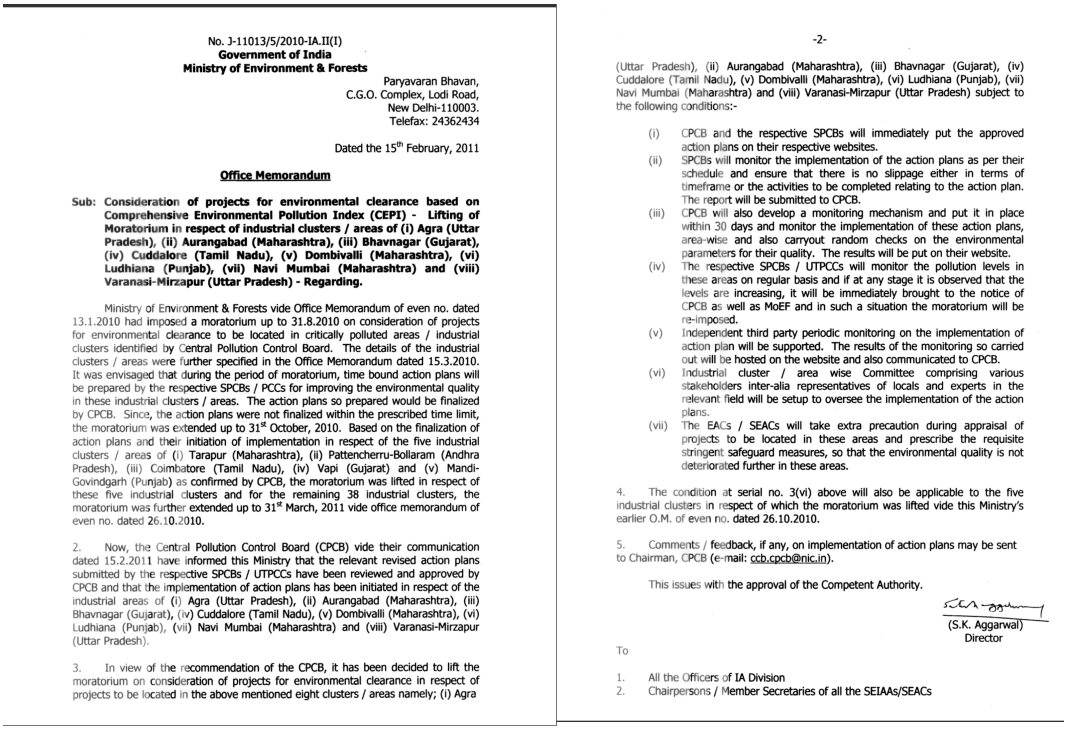
4. With the identification of industrial clusters / areas by CPCB which are critically or severely polluted, Ministry of Environment & Forests hereby imposes temporary restrictions on consideration of developmental projects in such clusters/ areas and prescribes the following procedure to be adopted with immediate effect:

4.1.1 The developmental projects from industrial clusters with CEPI score above 70 (as listed at serial no. 1 to 43 of the Annexure) received for grant of environmental clearance in terms of the provisions of EIA Notification, 2006 [including projects for stage-I clearance i.e. scoping (TORs)], which are presently in pipeline for environmental clearance or which would be received hereafter shall be returned to the project proponents.

4.1.2 This restriction on consideration of projects from critically polluted clusters/areas above will apply for a period of 8 months upto August, 2010 during which time the Central Pollution Control Board along with the respective State Pollution Control Boards / UT Pollution Control Committees will finalize a time bound action plan for improving the environmental quality in these identified clusters/ areas. The situation will be reviewed thereafter and further instructions issued accordingly; provided that projects relating to renewal of mining lease without any increase in production and / or lease area which are already in operation in these clusters will continue to be appraised in accordance with the procedure prescribed under EIA Notification, 2006 and decision taken on merits; and provided further that the projects of public interest, such as projects of national importance, pollution control, defence and security, with prior approval of the Competent Authority, MEF/ SEIAA for category 'A' & 'B' respectively, on a case to case basis, will continue to be appraised in accordance with the procedure prescribed under EIA Notification, 2006 and decision taken on merits.

4.2 The developmental projects from industrial clusters with CEPI score between 60 - 70 (as listed at serial no. 44 to 75 of the Annexure), which are in the pipeline or are received for grant of environmental clearance in terms of the provisions of EIA Notification, 2006 [including projects for stage-I clearance i.e. scoping (TORs)], will be considered following the procedure outlined in this Ministry's earlier circular no. J-11013/18/2009-IA.II(I) dated 25th August, 2009 relating to 'proposals for environment clearance for the projects located in the critically polluted areas as identified by the Central Pollution Control Board', which is available on the website of the Ministry www.envfor.nic.in.

Panel A: Circular dated 13.01.2010



No. J-11013/5/2010-IA.II(I)
Government of India
Ministry of Environment & Forests

Paryavaran Bhavan,
C.G.O. Complex, Lodi Road,
New Delhi-110003.
Telefax: 24362434

Dated the 15th February, 2011

Office Memorandum

Sub: Consideration of projects for environmental clearance based on Comprehensive Environmental Pollution Index (CEPI) - Lifting of Moratorium in respect of industrial clusters / areas of (i) Agra (Uttar Pradesh), (ii) Aurangabad (Maharashtra), (iii) Bhavnagar (Gujarat), (iv) Cuddalore (Tamil Nadu), (v) Dombivalli (Maharashtra), (vi) Ludhiana (Punjab), (vii) Navi Mumbai (Maharashtra) and (viii) Varanasi-Mirzapur (Uttar Pradesh) - Regarding.

Ministry of Environment & Forests vide Office Memorandum of even no. dated 13.1.2010 had imposed a moratorium up to 31.8.2010 on consideration of projects for environmental clearance to be located in critically polluted areas / industrial clusters identified by Central Pollution Control Board. The details of the industrial clusters / areas were further specified in the Office Memorandum dated 15.3.2010. It was envisaged that during the period of moratorium, time bound action plans will be prepared by the respective SPCBs / PCCs for improving the environmental quality in these industrial clusters / areas. The action plans so prepared would be finalized by CPCB. Since, the action plans were not finalized within the prescribed time limit, the moratorium was extended up to 31st October, 2010. Based on the finalization of action plans and their initiation of implementation in respect of the five industrial clusters / areas of (i) Tarapur (Maharashtra), (ii) Pattencherru-Bollaram (Andhra Pradesh), (iii) Coimbatore (Tamil Nadu), (iv) Vapi (Gujarat) and (v) Mandi-Govindgarh (Punjab) as confirmed by CPCB, the moratorium was lifted in respect of these five industrial clusters and for the remaining 38 industrial clusters, the moratorium was further extended up to 31st March, 2011 vide office memorandum of even no. dated 26.10.2010.

2. Now, the Central Pollution Control Board (CPCB) vide their communication dated 15.2.2011 have informed this Ministry that the relevant revised action plans submitted by the respective SPCBs / UTPCCs have been reviewed and approved by CPCB and that the implementation of action plans has been initiated in respect of the industrial areas of (i) Agra (Uttar Pradesh), (ii) Aurangabad (Maharashtra), (iii) Bhavnagar (Gujarat), (iv) Cuddalore (Tamil Nadu), (v) Dombivalli (Maharashtra), (vi) Ludhiana (Punjab), (vii) Navi Mumbai (Maharashtra) and (viii) Varanasi-Mirzapur (Uttar Pradesh).

3. In view of the recommendation of the CPCB, it has been decided to lift the moratorium on consideration of projects for environmental clearance in respect of projects to be located in the above mentioned eight clusters / areas namely; (i) Agra

-2-

(Uttar Pradesh), (ii) Aurangabad (Maharashtra), (iii) Bhavnagar (Gujarat), (iv) Cuddalore (Tamil Nadu), (v) Dombivalli (Maharashtra), (vi) Ludhiana (Punjab), (vii) Navi Mumbai (Maharashtra) and (viii) Varanasi-Mirzapur (Uttar Pradesh) subject to the following conditions:-

(i) CPCB and the respective SPCBs will immediately put the approved action plans on their respective websites.
(ii) SPCBs will monitor the implementation of the action plans as per their schedule and ensure that there is no slippage either in terms of timeframe or the activities to be completed relating to the action plan. The report will be submitted to CPCB.
(iii) CPCB will also develop a monitoring mechanism and put it in place within 30 days and monitor the implementation of these action plans, area-wise and also carryout random checks on the environmental parameters for their quality. The results will be put on their website.
(iv) The respective SPCBs / UTPCCs will monitor the pollution levels in these areas on regular basis and if at any stage it is observed that the levels are increasing, it will be immediately brought to the notice of CPCB as well as MoEF and in such a situation the moratorium will be re-imposed.
(v) Independent third party periodic monitoring on the implementation of action plan will be supported. The results of the monitoring so carried out will be hosted on the website and also communicated to CPCB.
(vi) Industrial cluster / area wise Committee comprising various stakeholders inter-alia representatives of locals and experts in the relevant field will be setup to oversee the implementation of the action plans.
(vii) The EACs / SEACs will take extra precaution during appraisal of projects to be located in these areas and prescribe the requisite stringent safeguard measures, so that the environmental quality is not deteriorated further in these areas.

4. The condition at serial no. 3(vi) above will also be applicable to the five industrial clusters in respect of which the moratorium was lifted vide this Ministry's earlier O.M. of even no. dated 26.10.2010.

5. Comments / feedback, if any, on implementation of action plans may be sent to Chairman, CPCB (e-mail: ccb.cpcb@nic.in).

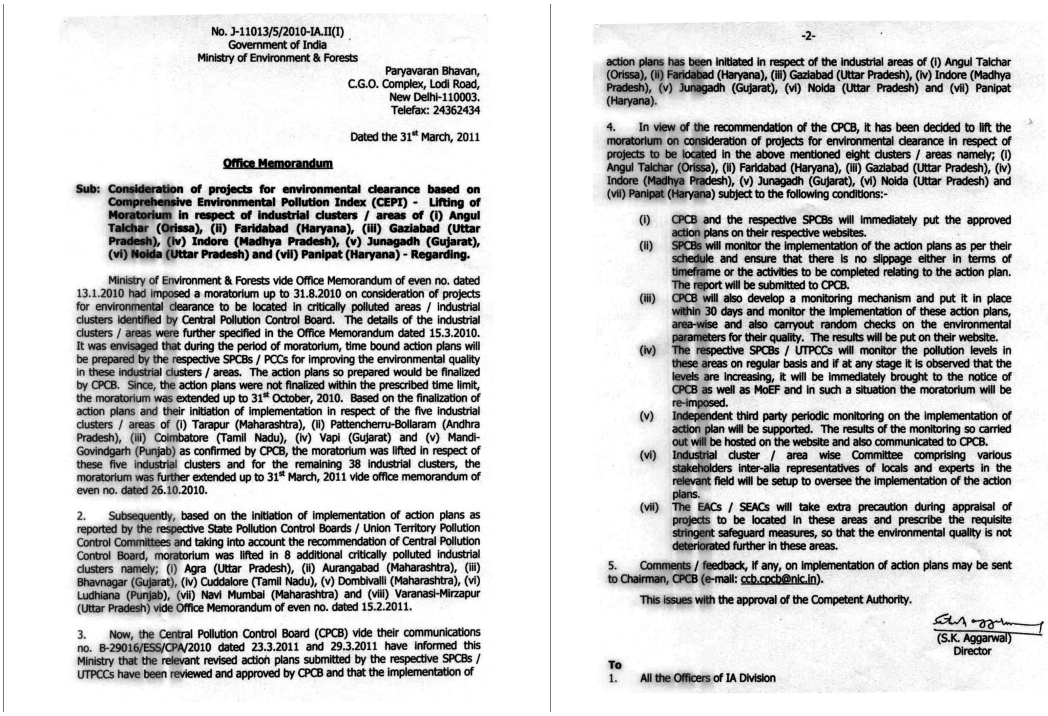
This issues with the approval of the Competent Authority.

(S.K. Aggarwal)
Director

To

1. All the Officers of IA Division
2. Chairpersons / Member Secretaries of all the SEIAAs/SEACs

Panel B: Circular dated 15.02.2011



No. J-11013/5/2010-IA.II(I)
Government of India
Ministry of Environment & Forests

Paryavaran Bhavan,
C.G.O. Complex, Lodi Road,
New Delhi-110003.
Telefax: 24362434

Dated the 31st March, 2011

Office Memorandum

Sub: Consideration of projects for environmental clearance based on Comprehensive Environmental Pollution Index (CEPI) - Lifting of Moratorium in respect of industrial clusters / areas of (i) Angul Talchar (Orissa), (ii) Faridabad (Haryana), (iii) Gaziabad (Uttar Pradesh), (iv) Indore (Madhya Pradesh), (v) Junagadh (Gujarat), (vi) Noida (Uttar Pradesh) and (vii) Panipat (Haryana) - Regarding.

Ministry of Environment & Forests vide Office Memorandum of even no. dated 13.1.2010 had imposed a moratorium up to 31.8.2010 on consideration of projects for environmental clearance to be located in critically polluted areas / industrial clusters identified by Central Pollution Control Board. The details of the industrial clusters / areas were further specified in the Office Memorandum dated 15.3.2010. It was envisaged that during the period of moratorium, time bound action plans will be prepared by the respective SPCBs / PCCs for improving the environmental quality in these industrial clusters / areas. The action plans so prepared would be finalized by CPCB. Since, the action plans were not finalized within the prescribed time limit, the moratorium was extended up to 31st October, 2010. Based on the finalization of action plans and their initiation of implementation in respect of the five industrial clusters / areas of (i) Tarapur (Maharashtra), (ii) Pattencherru-Bollaram (Andhra Pradesh), (iii) Coimbatore (Tamil Nadu), (iv) Vapi (Gujarat) and (v) Mandi-Govindgarh (Punjab) as confirmed by CPCB, the moratorium was lifted in respect of these five industrial clusters and for the remaining 38 industrial clusters, the moratorium was further extended up to 31st March, 2011 vide office memorandum of even no. dated 26.10.2010.

2. Subsequently, based on the initiation of implementation of action plans as reported by the respective State Pollution Control Boards / Union Territory Pollution Control Committees and taking into account the recommendation of Central Pollution Control Board, moratorium was lifted in 8 additional critically polluted industrial clusters namely; (i) Agra (Uttar Pradesh), (ii) Aurangabad (Maharashtra), (iii) Bhavnagar (Gujarat), (iv) Cuddalore (Tamil Nadu), (v) Dombivalli (Maharashtra), (vi) Ludhiana (Punjab), (vii) Navi Mumbai (Maharashtra) and (viii) Varanasi-Mirzapur (Uttar Pradesh) vide Office Memorandum of even no. dated 15.2.2011.

3. Now, the Central Pollution Control Board (CPCB) vide their communications no. B-29016/ESS/CPA/2010 dated 23.3.2011 and 29.3.2011 have informed this Ministry that the relevant revised action plans submitted by the respective SPCBs / UTPCCs have been reviewed and approved by CPCB and that the implementation of

-2-

action plans has been initiated in respect of the industrial areas of (i) Angul Talchar (Orissa), (ii) Faridabad (Haryana), (iii) Gaziabad (Uttar Pradesh), (iv) Indore (Madhya Pradesh), (v) Junagadh (Gujarat), (vi) Noida (Uttar Pradesh) and (vii) Panipat (Haryana).

4. In view of the recommendation of the CPCB, it has been decided to lift the moratorium on consideration of projects for environmental clearance in respect of projects to be located in the above mentioned eight clusters / areas namely; (i) Angul Talchar (Orissa), (ii) Faridabad (Haryana), (iii) Gaziabad (Uttar Pradesh), (iv) Indore (Madhya Pradesh), (v) Junagadh (Gujarat), (vi) Noida (Uttar Pradesh) and (vii) Panipat (Haryana) subject to the following conditions:-

(i) CPCB and the respective SPCBs will immediately put the approved action plans on their respective websites.
(ii) SPCBs will monitor the implementation of the action plans as per their schedule and ensure that there is no slippage either in terms of timeframe or the activities to be completed relating to the action plan. The report will be submitted to CPCB.
(iii) CPCB will also develop a monitoring mechanism and put it in place within 30 days and monitor the implementation of these action plans, area-wise and also carryout random checks on the environmental parameters for their quality. The results will be put on their website.
(iv) The respective SPCBs / UTPCCs will monitor the pollution levels in these areas on regular basis and if at any stage it is observed that the levels are increasing, it will be immediately brought to the notice of CPCB as well as MoEF and in such a situation the moratorium will be re-imposed.
(v) Independent third party periodic monitoring on the implementation of action plan will be supported. The results of the monitoring so carried out will be hosted on the website and also communicated to CPCB.
(vi) Industrial cluster / area wise Committee comprising various stakeholders inter-alia representatives of locals and experts in the relevant field will be setup to oversee the implementation of the action plans.
(vii) The EACs / SEACs will take extra precaution during appraisal of projects to be located in these areas and prescribe the requisite stringent safeguard measures, so that the environmental quality is not deteriorated further in these areas.

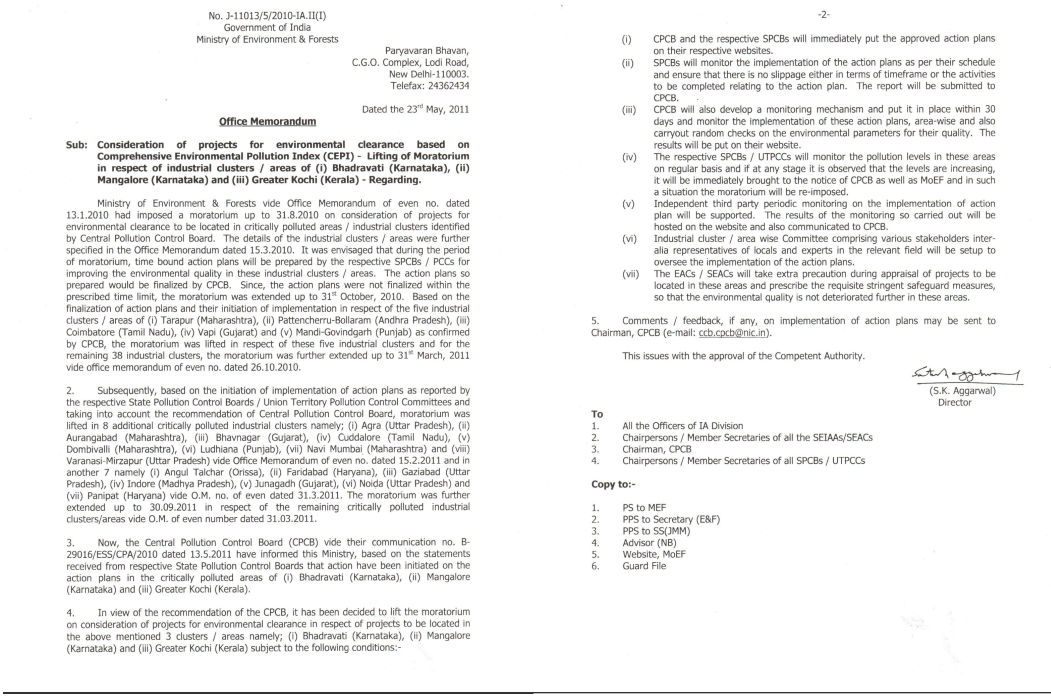
5. Comments / feedback, if any, on implementation of action plans may be sent to Chairman, CPCB (e-mail: ccb.cpcb@nic.in).

This issues with the approval of the Competent Authority.

(S.K. Aggarwal)
Director

To
1. All the Officers of IA Division

Panel C: Circular dated 31.03.2011



No. J-11013/5/2010-IA.II(I)
Government of India
Ministry of Environment & Forests

Paryavaran Bhavan,
C.G.O. Complex, Lodi Road,
New Delhi-110003.
Telefax: 24362434

Dated the 23rd May, 2011

Office Memorandum

Sub: Consideration of projects for environmental clearance based on Comprehensive Environmental Pollution Index (CEPI) - Lifting of Moratorium in respect of industrial clusters / areas of (i) Bhadravati (Karnataka), (ii) Mangalore (Karnataka) and (iii) Greater Kochi (Kerala) - Regarding.

Ministry of Environment & Forests vide Office Memorandum of even no. dated 13.1.2010 had imposed a moratorium up to 31.8.2010 on consideration of projects for environmental clearance to be located in critically polluted areas / industrial clusters identified by Central Pollution Control Board. The details of the industrial clusters / areas were further specified in the Office Memorandum dated 15.3.2010. It was envisaged that during the period of moratorium, time bound action plans will be prepared by the respective SPCBs / PCCs for improving the environmental quality in these industrial clusters / areas. The action plans so prepared would be finalized by CPCB. Since, the action plans were not finalized within the prescribed time limit, the moratorium was extended up to 31st October, 2010. Based on the finalization of action plans and their initiation of implementation in respect of the five industrial clusters / areas of (i) Tarapur (Maharashtra), (ii) Pattencherru-Bollaram (Andhra Pradesh), (iii) Coimbatore (Tamil Nadu), (iv) Vapi (Gujarat) and (v) Mandi-Govindgarh (Punjab) as confirmed by CPCB, the moratorium was lifted in respect of these five industrial clusters and for the remaining 38 industrial clusters, the moratorium was further extended up to 31st March, 2011 vide office memorandum of even no. dated 26.10.2010.

2. Subsequently, based on the initiation of implementation of action plans as reported by the respective State Pollution Control Boards / Union Territory Pollution Control Committees and taking into account the recommendation of Central Pollution Control Board, moratorium was lifted in 8 additional critically polluted industrial clusters namely; (i) Agra (Uttar Pradesh), (ii) Aurangabad (Maharashtra), (iii) Bhavnagar (Gujarat), (iv) Cuddalore (Tamil Nadu), (v) Dombivalli (Maharashtra), (vi) Ludhiana (Punjab), (vii) Navi Mumbai (Maharashtra) and (viii) Varanasi-Mirzapur (Uttar Pradesh) vide Office Memorandum of even no. dated 15.2.2011 and in another 7 namely (i) Angul Talchar (Orissa), (ii) Faridabad (Haryana), (iii) Gaziabad (Uttar Pradesh), (iv) Indore (Madhya Pradesh), (v) Junagadh (Gujarat), (vi) Noida (Uttar Pradesh) and (vii) Panipat (Haryana) vide O.M. no. of even dated 31.3.2011. The moratorium was further extended up to 30.09.2011 in respect of the remaining critically polluted industrial clusters/areas vide O.M. of even number dated 31.03.2011.

3. Now, the Central Pollution Control Board (CPCB) vide their communication no. B-29016/ESS/CPA/2010 dated 13.5.2011 have informed this Ministry, based on the statements received from respective State Pollution Control Boards that action have been initiated on the action plans in the critically polluted areas of (i) Bhadravati (Karnataka), (ii) Mangalore (Karnataka) and (iii) Greater Kochi (Kerala).

4. In view of the recommendation of the CPCB, it has been decided to lift the moratorium on consideration of projects for environmental clearance in respect of projects to be located in the above mentioned 3 clusters / areas namely; (i) Bhadravati (Karnataka), (ii) Mangalore (Karnataka) and (iii) Greater Kochi (Kerala) subject to the following conditions:-

-2-

(i) CPCB and the respective SPCBs will immediately put the approved action plans on their respective websites.
(ii) SPCBs will monitor the implementation of the action plans as per their schedule and ensure that there is no slippage either in terms of timeframe or the activities to be completed relating to the action plan. The report will be submitted to CPCB.
(iii) CPCB will also develop a monitoring mechanism and put it in place within 30 days and monitor the implementation of these action plans, area-wise and also carryout random checks on the environmental parameters for their quality. The results will be put on their website.
(iv) The respective SPCBs / UTPCCs will monitor the pollution levels in these areas on regular basis and if at any stage it is observed that the levels are increasing, it will be immediately brought to the notice of CPCB as well as MoEF and in such a situation the moratorium will be re-imposed.
(v) Independent third party periodic monitoring on the implementation of action plan will be supported. The results of the monitoring so carried out will be hosted on the website and also communicated to CPCB.
(vi) Industrial cluster / area wise Committee comprising various stakeholders inter-alia representatives of locals and experts in the relevant field will be setup to oversee the implementation of the action plans.
(vii) The EACs / SEACs will take extra precaution during appraisal of projects to be located in these areas and prescribe the requisite stringent safeguard measures, so that the environmental quality is not deteriorated further in these areas.

5. Comments / feedback, if any, on implementation of action plans may be sent to Chairman, CPCB (e-mail: ccb.cpcb@nic.in).

This issues with the approval of the Competent Authority.

(S.K. Aggarwal)
Director

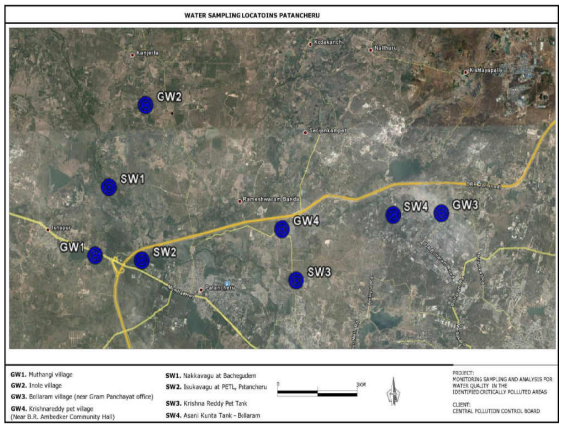
To
1. All the Officers of IA Division
2. Chairpersons / Member Secretaries of all the SEIAAs/SEACs
3. Chairman, CPCB
4. Chairpersons / Member Secretaries of all SPCBs / UTPCCs

Copy to:-

1. PS to MEF
2. PPS to Secretary (E&F)
3. PPS to SS(JMM)
4. Advisor (NB)
5. Website, MoEF
6. Guard File

Panel D: Circular dated 23.05.2011

FIGURE IAC3: MOEF&CC CIRCULARS



(a) Water sampling locations



Ambient Air Monitoring Station. Sujana Metals Unit-IV



Surface Water Sampling Point. Isukavagu



Ground Water Sample Point. Bollaram Village

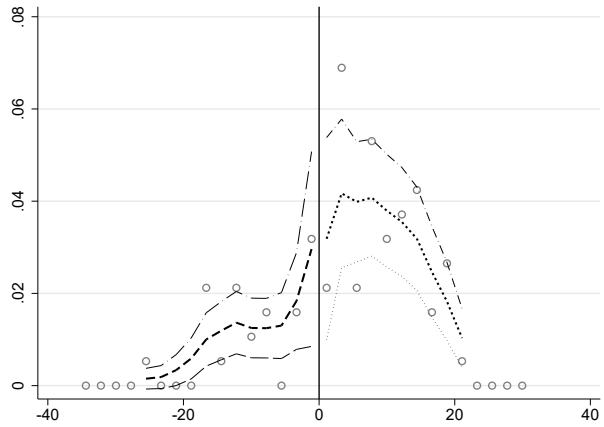


Ground Water Sample Point. Krishnareddypet

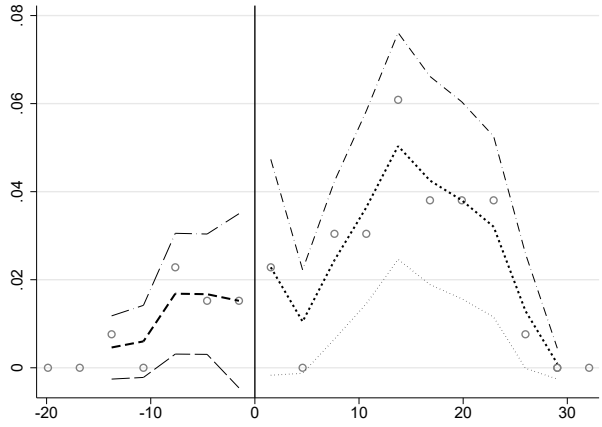
(b) Sampling documentation photos

FIGURE IAC4: PANTANCHERU-BOLLARAM CLUSTER POLLUTION MONITORING

This figure illustrates monitoring around the Pantancheru-Bollaram cluster. Panel (a) illustrates water sampling locations with the blue dots signifying water collection sites. Panel (b) documents sampling at these sites. Source: CPCB annual reports, "Sampling and Analysis of Ambient Air Quality and Water Quality in Industrial/Cluster Areas."



(a) 2011 CEPI



(b) 2013 CEPI

FIGURE IAC5: TEST FOR MANIPULATION OF THE CEPI IN 2011 AND 2013

This figure studies potential manipulation of CEPI. Panel (a) reports the fitted distribution of the 2011 CEPI update around the cutoff at 70 (normalized to zero) for clusters with a 2009 CEPI of at least 70 (Critically Polluted Areas). Panel (b) reports the fitted distribution of the 2013 CEPI update around the (updated) cutoff at 60 (normalized to zero) for the same sample. Source: CPCB.

holding firms accountable for their environmental impact was difficult with unreliable data and weak enforcement. Accordingly, the CPCB centralized control and broadened its scrutiny of emissions. It automated monitoring to the extent possible, increased auditor independence, and instigated overlapping monitoring regimes. Moreover, the CPCB increased engagement specific cutoffs defined escalating severity of regulatory scrutiny.

Appendix D Remedial Action Plans

In January 2010, 43 industrial clusters across India with CEPI values above 70 were required to formulate an action plan. These plans include targeted measures to tackle specific sources of pollution, such as stricter effluent and emission norms, upgrading pollution control facilities, and adopting cleaner technologies. The content of the action plans varied significantly across different states and clusters, depending on local environmental priorities and industrial activities. For example, the Howrah industrial cluster in West Bengal concentrated on enhancing air quality monitoring and controlling emissions from small-scale industries.

The action plans were implemented by the industries with oversight from state pollution control boards and other regulators. Regular monitoring and assessment were conducted to evaluate the effectiveness of these measures in reducing pollution. The action plan for Howrah, excerpted in Figure IAD6, included upgrading treatment plant technology, promoting the adoption of cleaner production techniques, and improving solid waste management practices to mitigate the impact of hazardous waste on the environment. The Howrah action plan includes the installation of a Common Effluent Treatment Plant (CETP), an Ambient Air Quality Monitoring system (AAAQM), and the development of a proper drainage facility. The plan includes deadlines and specifies about who bears implementation responsibility. In these examples, it is shared between industry associations, individual industries, the West Bengal Pollution Control Board (WBPCB), and the Ministry of Environment and Forests (MOEF). Finally, the action plan includes a projected cost. For example, installation of the treatment plant is projected at approximately 1.5 Crore INR (around 309,917 USD). The cost is expected to be shared between the industry association and the WBPCB. This example is from the Long Term Action points (to be completed in a year or later from agreement) in the category of water emissions. More generally, the action plans typically divide actions into short-term (less than one year) and long-term and between air, water, and land category emissions.

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.

FIGURE IAD6: INDUSTRY-LEVEL ABATEMENT EVIDENCE FROM ACTION PLANS

This figure reports anecdotal evidence collected from the action plan of the Howrah industrial cluster in West Bengal on specific abatement actions to be taken in the long-term (deadline more than one year) for industrial water emissions. Source: CPCB.

Action plans also included actions for specific firms. Figure IAD7 is an example from the action plan for the action plan for Haldia in West Bengal. Here we observe specific actions to reduce air, water and land-category impact, including the technology to be adopted.

Name	Technology adopted during last one year			Time frame	Remarks
	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	1.5 Crs 20 Crs 40 lakhs / year since last two months 850 Crs

FIGURE IAD7: FIRM LEVEL ABATEMENT EVIDENCE FROM ACTION PLANS

This figure reports anecdotal evidence collected from the action plan of the Haldia industrial cluster in West Bengal on specific abatement actions to be taken by Tata Chemicals Limited for the fiscal year 2011 Source: CPCB.

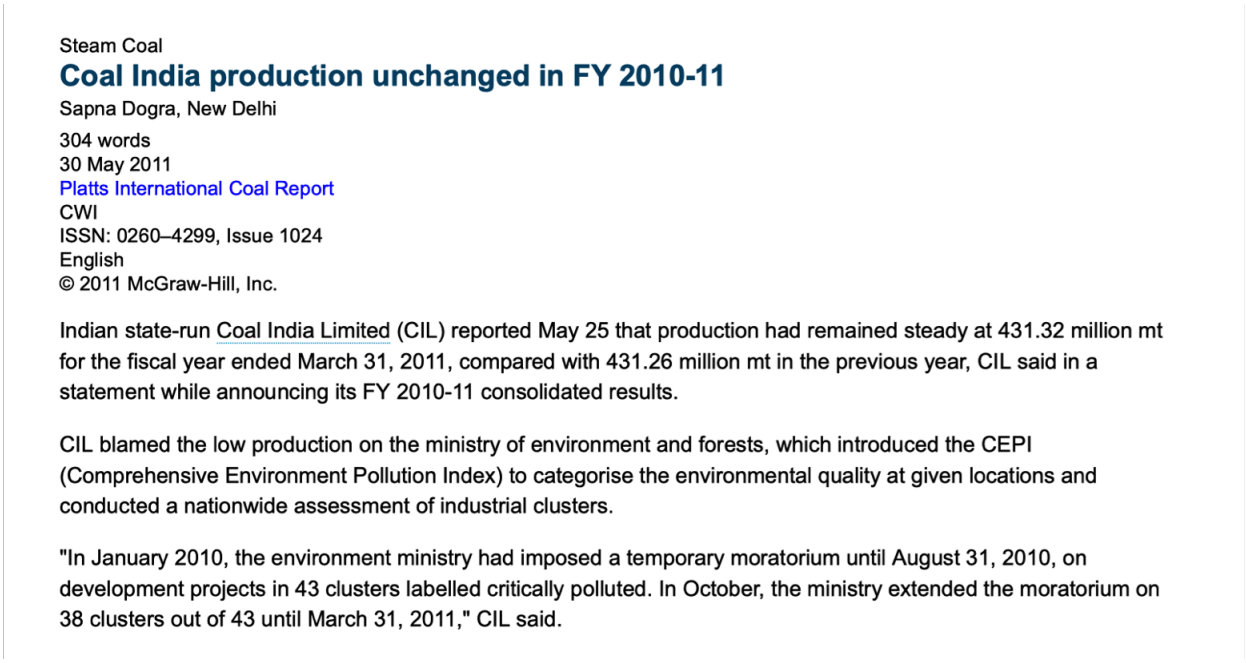
We also observe evidence from the annual reports of listed firms of the types of actions treated firms undertook to reduce their emissions. Annual reports are mandated by the Companies Act, 1956 and include details about firm financial performance, corporate governance, and strategic initiatives. In particular, we examine the sections on corporate social responsibility activities, management discussion and analysis (MD&A), and disclosures on risks and opportunities. In Figure IAD8 we include an example excerpt for JK Lakshmi Cement Limited in the Ankleshwar industrial cluster in Gujarat for fiscal year 2012 (calendar year 2011), the year following the implementation of the action plan in Ankleshwar. We see that the firm specifically mentions that they reduced their energy inputs overall and that they switched to greener energy sources. This is anecdotal evidence that supports the robust finding in Table **??** that the average treated firm took these exact actions.

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.

FIGURE IAD8: FIRM LEVEL EVIDENCE FROM AUDITED ANNUAL REPORT

This figure reports anecdotal evidence collected from firm annual reports. It illustrates specific abatement actions taken JK Lakshmi Cement Limited, located in the Ankleshwar industrial cluster in Gujarat, for the fiscal year 2012.

If the cluster's CEPI values failed to improve, then the industries that did not implement action were barred from expanding, either existing businesses or new entrants. We observe emissions significantly decrease for treated relative to control firms (see Section 4), which supports our hypothesis of credible enforcement, on average. We also observe media reports of both successful and unsuccessful enforcement. For example, Figure IAD9 blames the CEPI regulation for missed production targets at Coal India Limited, an important state-owned enterprise and the largest government-owned-coal-producer in the world. Specifically, Coal India was not allowed to expand production in clusters with a 2009 CEPI of at least 70.



Steam Coal

Coal India production unchanged in FY 2010-11

Sapna Dogra, New Delhi

304 words
30 May 2011
Platts International Coal Report
CWI
ISSN: 0260–4299, Issue 1024
English
© 2011 McGraw-Hill, Inc.

Indian state-run Coal India Limited (CIL) reported May 25 that production had remained steady at 431.32 million mt for the fiscal year ended March 31, 2011, compared with 431.26 million mt in the previous year, CIL said in a statement while announcing its FY 2010-11 consolidated results.

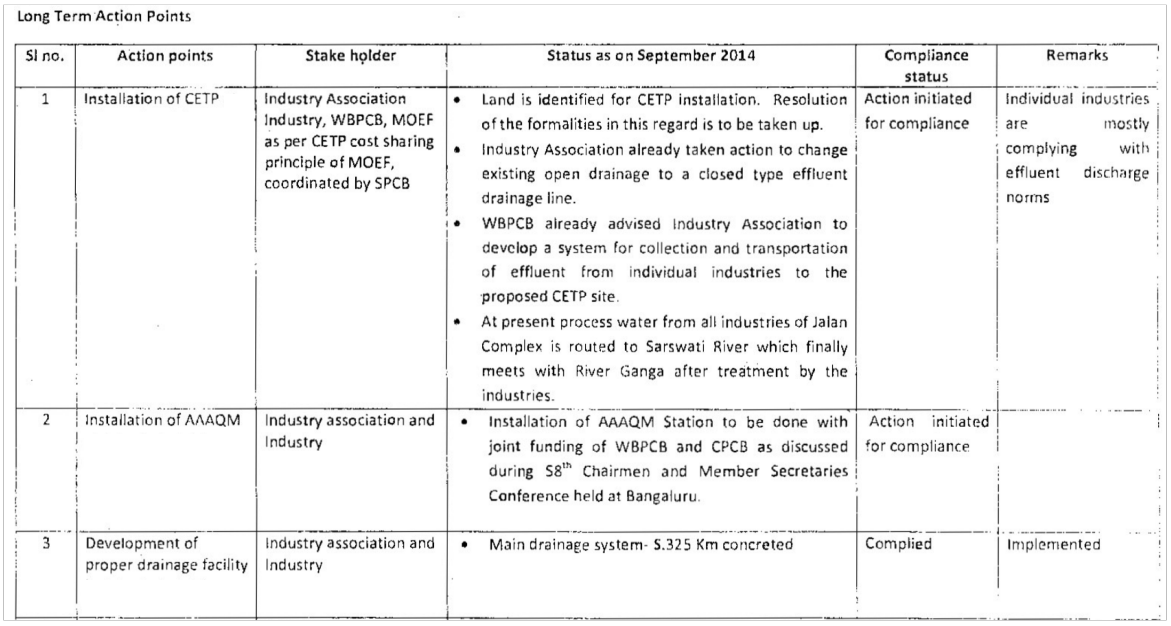
CIL blamed the low production on the ministry of environment and forests, which introduced the CEPI (Comprehensive Environment Pollution Index) to categorise the environmental quality at given locations and conducted a nationwide assessment of industrial clusters.

"In January 2010, the environment ministry had imposed a temporary moratorium until August 31, 2010, on development projects in 43 clusters labelled critically polluted. In October, the ministry extended the moratorium on 38 clusters out of 43 until March 31, 2011," CIL said.

FIGURE IAD9: EXAMPLE ENFORCEMENT EVIDENCE FROM MEDIA

This figure reports anecdotal evidence collected from media reports of compliance with the action plans for industrial clusters with CEPI of 70 or greater. The article discusses the adverse impact of the regulation on coal production of Coal India Limited. Source: Factiva, Platts International Coal Report.

If instead the CEPI values improved and pollution levels decreased significantly, then the clusters would continue to be subject to regular pollution audits and continuous monitoring stations but would otherwise not be prevented from expanding. From Figure 3a, we can see that compliance with these action plans varied, with some clusters that had a CEPI of 70 or over improving their follow-on CEPI in 2011 and 2013 significantly and others only marginally. We have also gathered regulatory documents assessing compliance with action plans at the cluster level. Figure IAD10 is from a follow-up assessment of the Howrah action plan in September 2014 of the items excerpted in Figure IAD6. We can see that progress is recorded in all three areas, but only one (drainage) was completed by September 2014, despite the original plan calling for compliance by June 2012. In general, we observe that regulator capacity and strong industry groups played a key role in achieving the action plan directives. States like Gujarat and Maharashtra, with well-established industrial bases and stronger regulatory frameworks, saw more rigorous enforcement and regular monitoring. However, in states with less regulatory capacity, such as Uttar Pradesh or West Bengal, enforcement was less consistent, leading to varied levels of compliance and effectiveness.



Long Term Action Points

Sl no.	Action points	Stake holder	Status as on September 2014	Compliance status	Remarks
1	Installation of CETP	Industry Association Industry, WBPCB, MOEF as per CETP cost sharing principle of MOEF, coordinated by SPCB	• Land is identified for CETP installation. Resolution of the formalities in this regard is to be taken up. • Industry Association already taken action to change existing open drainage to a closed type effluent drainage line. • WBPCB already advised Industry Association to develop a system for collection and transportation of effluent from individual industries to the proposed CETP site. • At present process water from all industries of Jalan Complex is routed to Sarswati River which finally meets with River Ganga after treatment by the industries.	Action initiated for compliance	Individual industries are mostly complying with effluent discharge norms
2	Installation of AAAQM	Industry association and Industry	• Installation of AAAQM Station to be done with joint funding of WBPCB and CPCB as discussed during 58th Chairmen and Member Secretaries Conference held at Bangaluru.	Action initiated for compliance	
3	Development of proper drainage facility	Industry association and Industry	• Main drainage system- 5.325 Km concreted	Complied	Implemented

FIGURE IAD10: ABATEMENT EVIDENCE FROM ACTION PLAN ASSESSMENT

This figure reports anecdotal evidence collected from regulatory assessments of compliance with the action plans for industrial clusters with CEPI of 70 or greater. It illustrates follow up on long-term (deadline more than one year) action points to reduce industrial water emissions in the Howrah industrial cluster in West Bengal. Source: CPCB.

D.1 Construction of Word Clouds from Industrial Action Plans

This appendix outlines how we process textual data from industrial action plans and to generate word clouds summarizing key themes across states and for India overall. The objective of these visualizations is to highlight the most frequent concepts related to pollution-abatement investments and technologies mentioned in the plans.

Data and Preprocessing

The raw data consist of industrial action plans compiled across states. Each observation includes a free-form textual description of specific activities or investments undertaken to reduce pollution in industrial clusters.

The analysis retains descriptions and excludes entries with missing text. We then standardize the text by removing URLs, punctuation, and special characters, and by collapsing redundant whitespace. This yields a clean corpus of sentences describing planned and ongoing mitigation measures.

Semantic Filtering

Because the original text includes both administrative and technical content, we apply a semantic filtering procedure to focus on sentences related to abatement investments. Using a large-language-model embedding approach, each sentence is compared with a reference embedding representing the concept of "abatement investments and technologies that help reduce pollution." Sentences with high semantic similarity to this concept are retained. This filtering ensures that the analysis emphasizes substantive abatement actions rather than procedural details.

Word Cloud Generation

Word clouds are generated at two levels of aggregation:

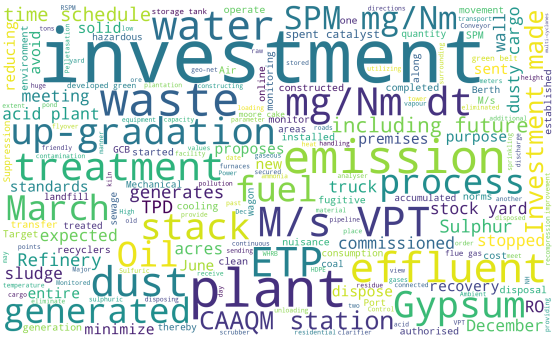
- **State-Level Word Clouds:** The cleaned and filtered text is grouped by state, and a separate word cloud is produced for each. Each visualization illustrates the relative prominence of terms describing abatement activities within that state's industrial action plans.
- **National Word Cloud:** All state corpora are combined into a single corpus to produce a national-level word cloud that captures aggregate patterns across the country.

Stopword Refinement and Visualization Parameters

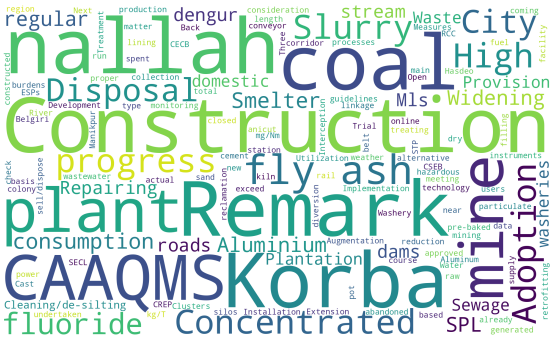
To enhance interpretability, and common in the literature, standard English stopwords are supplemented with domain-specific terms frequently found in administrative documents but unrelated to pollution control (e.g., "action," "report," "status," "project," "system," and numeric terms such as "crore" or "year"). The word size is proportional to its frequency.

Interpretation

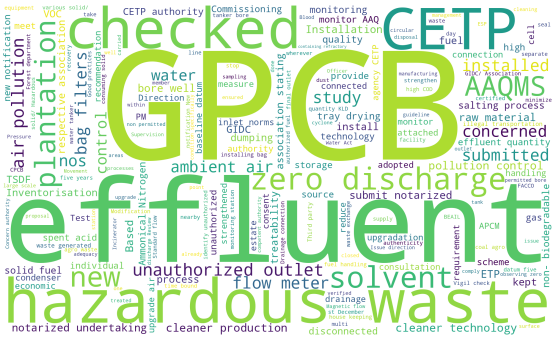
Wordclouds summarize the thematic focus of the industrial action plans in an interpretable, text-based format. The most prominent words correspond to the most frequently mentioned technologies and interventions—such as waste treatment, effluent recycling, and emission-control systems—providing an overview of abatement priorities at both state and national levels.



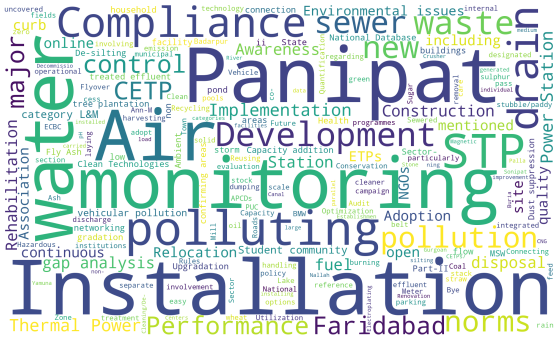
(a) Andhra Pradesh



(b) Chhattisgarh



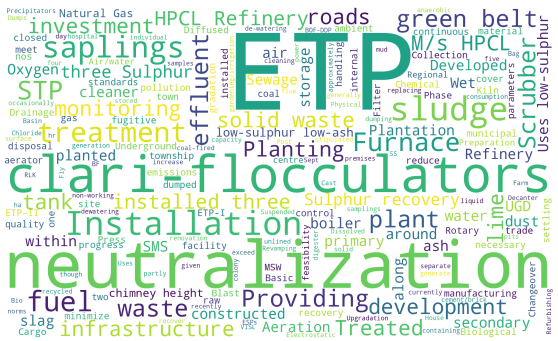
(c) Gujarat



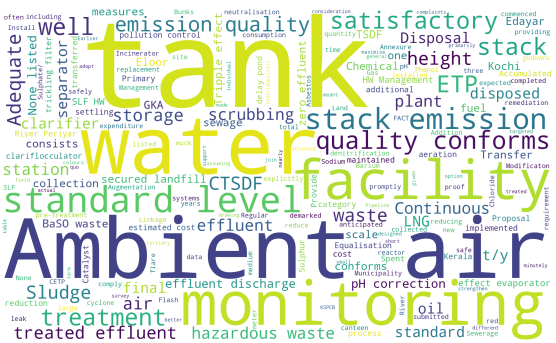
(d) Haryana



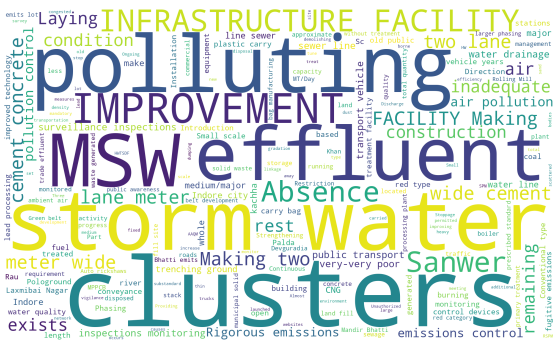
(e) Jharkhand



(f) Karnataka



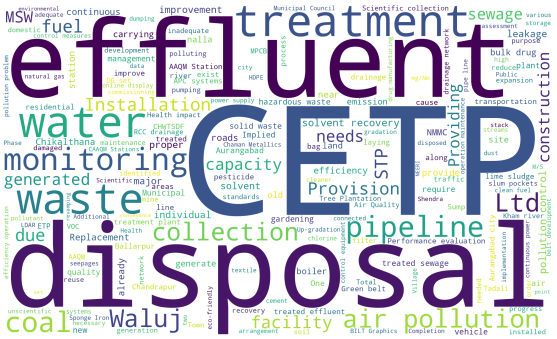
(g) Kerala



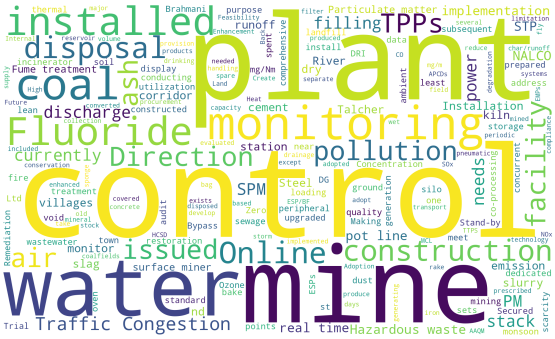
(h) Madhya Pradesh

FIGURE IAD11: TECHNOLOGIES IN ABATEMENT WORD CLOUDS BY INDIAN STATE (PANEL SET 1 OF 2).

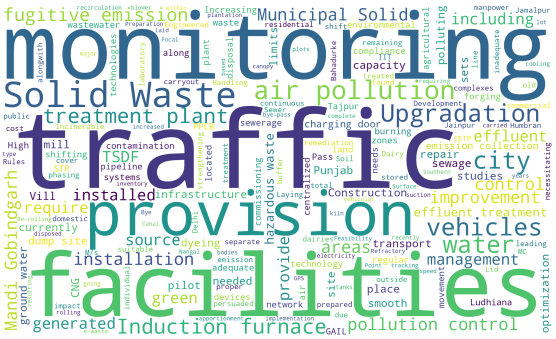
Notes: Panels (a)–(h) appear in reading order (left to right, top to bottom): (a) Andhra Pradesh, (b) Chhattisgarh, (c) Gujarat, (d) Haryana, (e) Jharkhand, (f) Karnataka, (g) Kerala, (h) Madhya Pradesh.



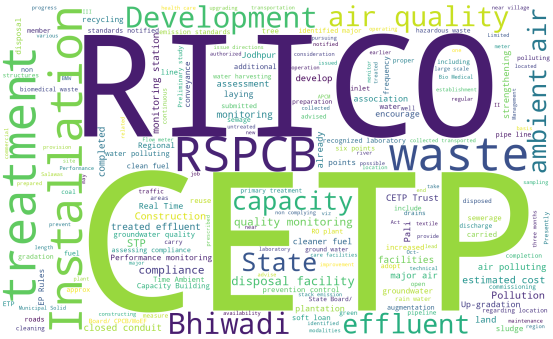
(i) Maharashtra



(j) Odisha



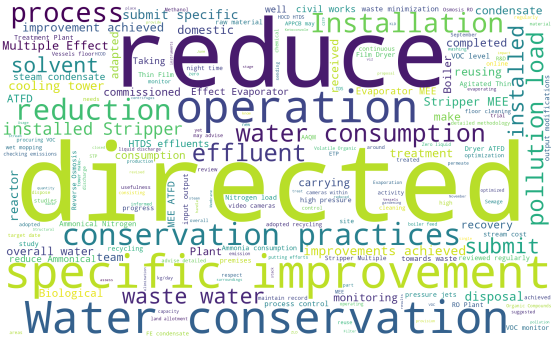
(k) Punjab



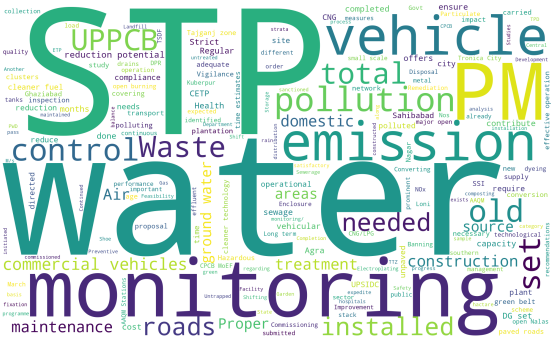
(l) Rajasthan



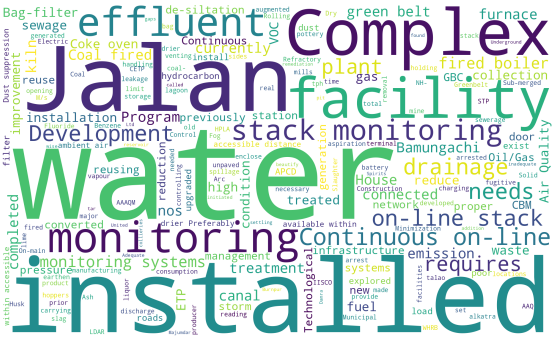
(m) Tamil Nadu



(n) Telangana



(o) Uttar Pradesh



(p) West Bengal

FIGURE IAD11: TECHNOLOGIES IN ABATEMENT WORD CLOUDS BY INDIAN STATE (PANEL SET 2 OF 2).

Notes: Panels (i)–(p) appear in reading order (left to right, top to bottom): (i) Maharashtra, (j) Odisha, (k) Punjab, (l) Rajasthan, (m) Tamil Nadu, (n) Telangana, (o) Uttar Pradesh, (p) West Bengal.

Appendix E Determinants of Compliance

In this section, we explore heterogeneity in CEPI improvement using hand-collected CEPI reassessments in 2011 and 2013 for $CEPI^{[70,100]}$ clusters (according to the 2009 ranking). We first confirm a large average CEPI improvement, which agrees with the evidence of cluster- and product-level emissions reduction. Next, we characterize what regulator and cluster characteristics predict improvement. In agreement with the literature on regulation enforcement, we find that regulator reputation and lower corruption is key. This underscores the sharp test from our main treatment, which was to switch a relatively weak, local emissions regulator with a relatively strong, state-level one.

The top panel of Figure 2 reproduces the original 2009 CEPI distribution. The vertical line represents the cutoff at 70. The bottom panel reports the distributions of the recalculated CEPI values for the 2009 $CEPI^{[70,100]}$ clusters in 2011 and 2013. The distributions shifted to the left in both follow-up assessments, with significant improvement continuing between 2011 and 2013. We also observe that while the average cluster improved, several clusters continued to have CEPI values above the cutoffs in 2013, indicating the difficulties of mandating pollution below a certain threshold.[33]

Next, we investigate what city- and state-level covariates predict the degree of change in the city's CEPI by 2013 versus 2009 for clusters with a 2009 CEPI of at least 70 (ΔCEPI2013 $-$ 2009). Figure IAE12 presents scatter plots illustrating the relationship between each covariate (x-axis) and the change in CEPI score between 2013 and 2009 ($\Delta CEPI_{2013-2009}$) on the y-axis. These relationships have been residualized to account for the influence of other covariates in the model, ensuring that the plotted relationships reflect the partial effect of each focus covariate. We report the slope of the best-fit line above each sub-figure. A negative $\Delta CEPI2013 - 2009$ indicates improvement; zero indicates no change; a positive value indicates worsening environmental impact.

The top row of Figure IAE12 looks at regulator-level determinants of $\Delta CEPI2013 - 2009$. In panel (a) of Figure IAE12, we consider the Environmental Enforcement Index from Kattumuri and Lovo (2018), measuring historical state regulator effectiveness in implementing and enforcing environmental regulations, and judicial and media focus on environmental issues.[34] The direction of the correlation between the enforcement index and the change in CEPI is ex-ante ambiguous. More effective regulators might be associated with larger decreases in CEPI scores, reflecting more zealous enforcement of the 2009 reform. On the other hand, it could be that more effectively regulated areas are already relatively lower emitters and so improve by less. Panel (a) of Figure IAE12 reports a large and highly significantly negative association between the Environmental Enforcement Index and the change in the CEPI score between 2013 and 2009, i.e., a higher index value, associated with a more competent state environmental regulator, is associated with a more considerable improvement in emissions, as proxied by the CEPI.

Next, we examine evidence of cost-sharing between regulators and firms from the 2009 CEPI action plans, proxied by an indicator that takes the value of one if the action plan explicitly calls for cost sharing to implement required investments.[35] We predict that cities where regulators indicate cost-sharing in action plans will experience more substantial CEPI score reductions. Panel (b) of Figure IAE12 confirms that the correlation is indeed negative, large, and highly significant.

We also consider the correlation with survey-based 2008 state-level corruption scores from Transparency International, which asks a representative sample about their direct experiences with corruption. We see in panel (c) that the more corrupt the state, the less improvement in the CEPI score, even after controlling for the effect of the Environmental Enforcement Index, which incorporates a media-based corruption measure. Thus, we see that both aspects of corruption—its perception and its measurement—are important predictors of success.

The second row of Figure IAE12 reports the residualized relationship between CEPI improvement and cluster characteristics. In Panel (d) we examine cluster composition by firm size, a summary measure for many financial and information frictions.[36] The figure reports that the proportion of small firms in a city correlates significantly with improved (more negative) CEPI.

Next, clusters with more industry concentration may be better able to coordinate to reduce emissions. Panel (e) of Figure IAE12 reports that cities with more concentrated industries—proxied by industry-share weighted Herfindahl-Hirschman index (HHI)—improve significantly more, controlling for other factors like corruption.

Finally, we examine whether cities with prior Supreme Court-administered action plans (1996–2003) to reduce ve-

[33] We compiled a database of media assessments of the reform. It highlights examples from the tails of what we systematically observe here: clusters that greatly improved and others where pollution worsened.

[34] The 2006 index includes: (1) civic participation, proxied by environmental NGOs per capita; (2) judicial focus, measured as environmental judgments per capita; (3) state corruption as the number of corruption-related articles in major newspapers; (4) public awareness as the number of environment-related articles per capita; and (5) regulator monitoring capacity, proxied by the number of water monitoring stations per capita.

[35] See Appendix C for an example excerpted from the 2009 action plans, along with rich information on action plan format and enforcement.

[36] We define "small" firms using the regulatory standards in India: paid-up capital not exceeding INR 4 Crores and turnover not exceeding INR 40 Crores (Companies Act, 2013).

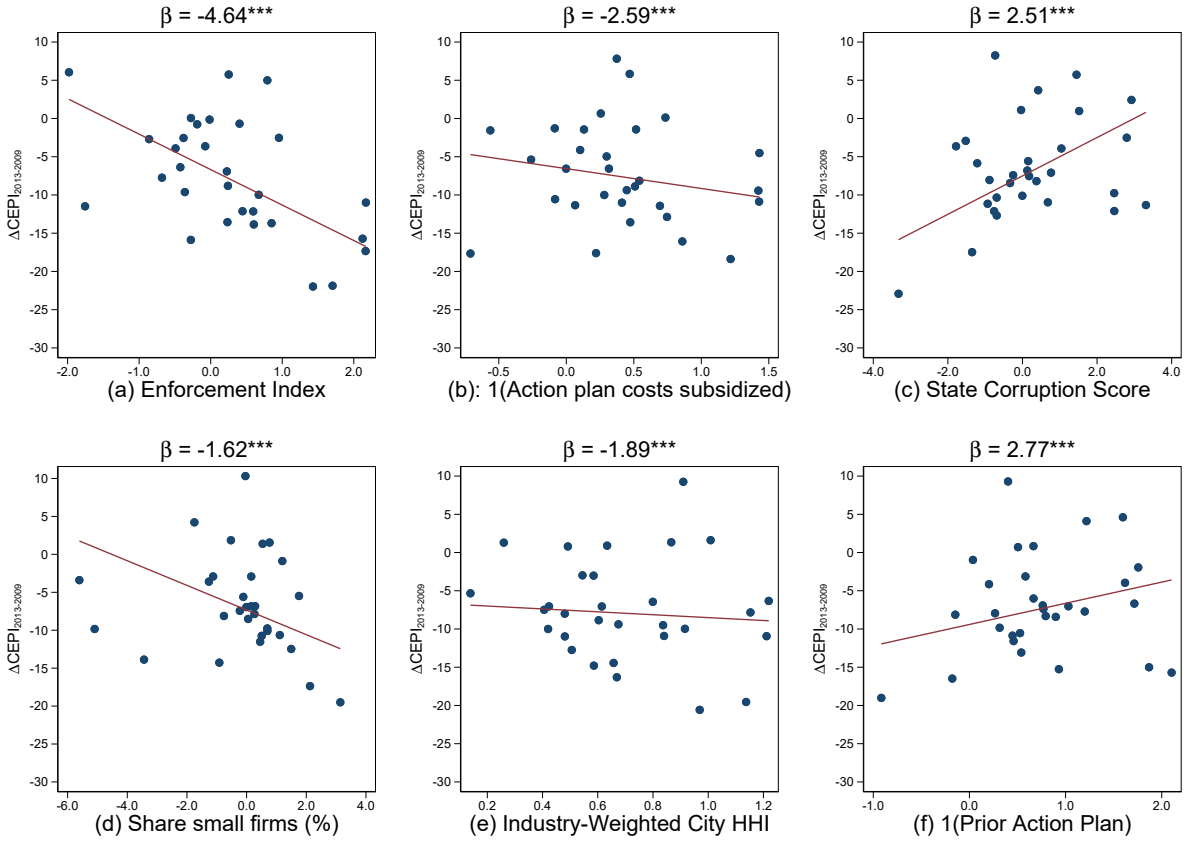


FIGURE IAE12: PRE-DETERMINED PREDICTORS OF IMPROVEMENT BY 2013

This figure investigates the determinants of CEPI improvement for clusters with a CEPI in 2009 of at least 70. Specifically, each panel presents the correlation between the change in the CEPI in 2013 versus 2009 (y-axis) and a pre-determined predictor of CEPI improvement, along with the line of best fit (red). The estimated slope (β) have been residualized to account for the influence of other covariates in the model, so that the plotted relationships reflect the partial effect of each focus covariate. We report the slope of the best-fit line above each sub-figure. The independent variable in panel (a) is the 2006 Environmental Enforcement Index of Kattumuri and Lovo (2018); in panel (b) it is an indicator for explicit regulator subsidies for technology adoption mandated in the cluster's 2010 CEPI action plan; in panel (c) it is the 2006 state corruption score from Transparency International; in panel (d) it is the share of small firms in the city in 2008; in panel (e) it is the weighted average across 2008 industry HHI, where weights are the proportion of sales the industry accounts for; and in panel (f) it is an indicator for a city having been the subject of a prior environmental action plan to reduce vehicular emissions, from Greenstone and Hanna (2014).

hicular emissions (Greenstone and Hanna, 2014) exhibit differential CEPI improvement. We define $1(\text{Prior Action Plan})$ as one if the city was subject to such a plan. The expected correlation is ambiguous: prior experience may enhance implementation or facilitate subversion. Panel (f) reports that cities that experienced a prior emissions regulation implemented through action plans had significantly less CEPI improvement by 2013 than those that had not.

The patterns depicted in Figure IAE12 are correlations. Yet they organize and complement our narrative and statistical evidence. The analysis suggests that the 2009 CEPI regulation's effectiveness is a function of regulator quality, regulation design, and cluster-specific characteristics.

Appendix F Measuring cluster-level pollution

The appendix provides a comprehensive overview of the methodology employed to compile the pollution data panel for each industrial site. We first discuss the Emission Database for Global Atmospheric Research (EDGAR) data, followed dataset by Van Donkelaar et al. (2021) (henceforth, Van Donkellaar). Finally, we detail the steps undertaken to construct the data panel.

F.1 Emission Database or Global Atmospheric Research (EDGAR)

Our primary pollution data comes from the Emission Database or Global Atmospheric Research (EDGAR), with particular emphasis on the Hemispheric Transport of Air Pollution ($HTAP_{v3}$) mosaic. This mosaic is designed to enhance the temporal range, sectoral breakdown, and geographical coverage of existing official data.[37] We use pollution data for nitrous oxide (NO_x), particles less than 2.5 µm in diameter ($PM_{2.5}$), and particles less than 10 µm in diameter (PM_{10}), are available, and each is processed distinctly. The monthly data with the highest resolution (0.1°x 0.1°) is downloaded. Upon reading this raster file, we keep only the industrial pollution layer, given its relevance to our study.

F.2 Fine Particulate Matter ($PM_{2.5}$) from Van Donkelaar et al. (2021)

We also use data from Van Donkelaar et al. (2021), as it offers monthly high-resolution (0.01° x 0.01° grid) estimates of ground-level fine particulate matter ($PM_{2.5}$). These pollution estimates are calculated by merging aerosol optical depth (AOD) data from NASA's MODIS, MISR, and SeaWiFS instruments with outputs from the GEOS-Chem chemical transport model. The dataset is refined through calibration with global ground-based observations via geographically weighted regression (GWR).

F.3 Measurement Procedure

The process of measuring pollution data at the industrial cluster level is broken down into four steps.

1. Extract the cluster location from the PDF titled "Assessment of the Need from Common Effluent Treatment Plants."
2. Geocode each identified location and construct corresponding circles around industrial areas/estate locations.
3. Using the location and pollution data from the previous step, we compute the weighted overlap between the designated circular region and the pollution raster layer.

(1) Extraction of Industrial Clusters: We use the document "Assessment of the Need from Common Effluent Treatment Plants," which is published by the CPCB under the Ministry of Environmental & Forest, Govt. of India. Starting from page 22 in Annexure II, it presents a list of industrial areas and estates of new locations categorized by state. Using this document, we extract these addresses into Excel using PDF converters. Given the document's inconsistencies, research assistants meticulously review the output by hand to guarantee accurate extraction.

(2) Geocoding and Shape Construction: Next, we pinpoint the latitude and longitude of industrial clusters. We send each address to the Google Maps API, and retrieve their geocodes. This helps exclude duplicate locations, proposals that weren't realized, and entries with incomplete information. After this step, we are left with 2914 locations. Using this refined list, a geometry, specifically a circle with a 500m radius, is constructed around each location.

(3) Weight Pollution Data: The final step involves calculating the pollution at each industrial location. For this purpose, we utilize raster files from EDGAR and Van Donkelaar, as discussed above, to assess pollution levels surrounding these sites.

A critical aspect to consider is that the vicinity of an industrial location can span multiple grid cells. To account for this, we calculate a weighted average of the pollution values. This involves determining the proportion of the industrial area's footprint overlapping each grid cell, which then serves as the weight for that cell. By summing these weighted values across the industrial area, we obtain a comprehensive dataset detailing pollution levels by industrial area, month, and pollutant type.

[37] See https://edgar.jrc.ec.europa.eu/dataset_htap_v3 for more information.

Annexure II

List of Industrial Areas /Estates

State/UT: Haryana

	Ambala Cant
1	HSIIDC Ambala
2	IGC Food Park, Phase-I, Saha
3	IGC Phase-II, Saha
	Bhiwani
4	HUDA Sec-21
5	HUDA Sec-21

FIGURE IAF13: SAMPLE FROM THE ASSESSMENT OF THE NEED FROM COMMON EFFLUENT TREATMENT PLANTS

This figure presents an excerpt from the Assessment of the Need from Common Effluent Treatment Plants document. It presents the first 5 observations from page 22.

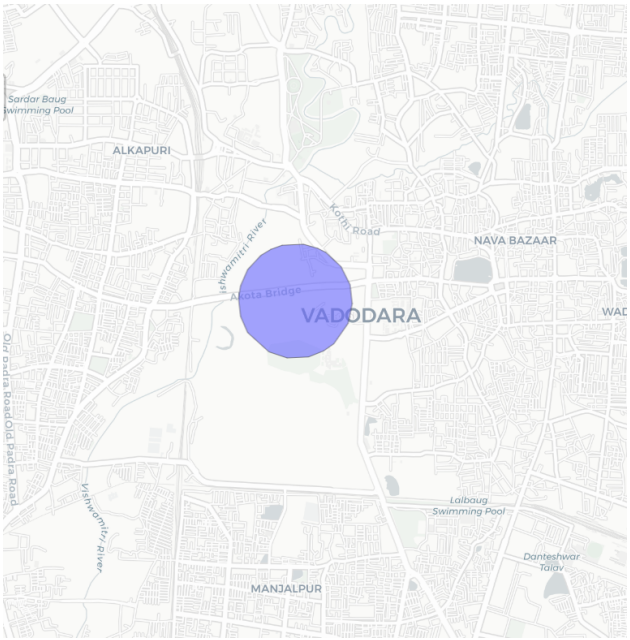


FIGURE IAF14: VADODARA, GUJARAT

This figure presents a shape drawn for a given industrial area/estate using a 500m radius.

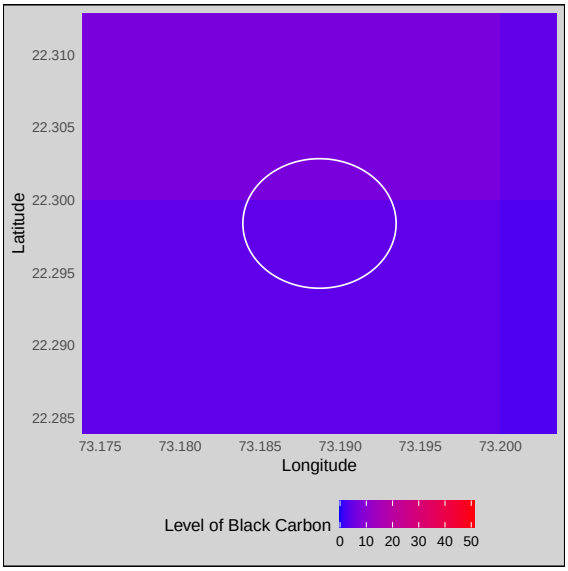


FIGURE IAF15: EXAMPLE OF INTERSECTION

This figure illustrates pollution calculations from December 2012, depicted as a circle divided into two segments: the top segment represents 27%, and the bottom segment represents 73%, indicating the proportional weight calculations

Appendix G Product-Level Emissions

This appendix describes how we clean the product-level energy inputs from the Prowess database and transform them into product-level CO_2 emissions. The Prowess product-wise energy consumption data are from company disclosures in their annual reports. Clause (e) of sub-section (1) of section 217 of the Companies Act of 1956 mandates that every company disclose *total* energy consumption in a prescribed format. However, there is no legal obligation to disclose the product-level energy consumption per unit of production. Thus, a limitation of this data is that firms choose whether or not to disclose it, and not every firm chooses to do so. However, once a firm starts reporting product-level energy inputs, however, it tends to continue to do so throughout the entire period. Note that this changes the interpretation of our results to be most directly applicable to these types of firms but is unlikely to violate the identification assumption of no discontinuity in the probability of reporting product-level energy assumption at CEPI treatment thresholds. Figure IAG16 provides evidence supporting this identification assumption.

TABLE IAG9: PROBABILITY OF FILING ENERGY INPUTS

This table reports the effect of the 2009 CEPI emissions regulation on the probability of reporting product-level energy inputs in firm annual reports. The unit of analysis is firm-product-year. Model (1) is on all firms in the Prowess database. Models (2) and (3) are on the regression dataset comprising manufacturing firms in clusters with CEPI within a bandwidth of 10 pollution index units around the cutoffs at 70 and 60. *Post* is an indicator variable taking the value of 1 for all years including 2009 the year in which reform was implemented and after. $CEPI^{[70,100]}$ takes the value of one if the industrial cluster has a CEPI value at or above 70, and zero otherwise. $CEPI^{[60,70)}$ takes the value of one if the industrial cluster has a CEPI value greater than or equal to 60 and below 70, and zero otherwise. In specifications (2) and (3), the sample is restricted to the 88 industrial clusters targeted by the CPCB in 2009 with the omitted category including clusters with a CEPI value below 60 and includes firm and State $\times$ two-digit Industry $\times$ year fixed effects. The standard errors are clustered at the city level and are robust to heteroscedasticity. ***, **, * denote significance at the 1%, 5%, and 10% level, respectively. All variables are defined in Appendix Table IAB8. Data source: CMIE Prowess.

Dependent variable:	$\mathbb{1}_{\text{File Energy Inputs}}$		
Sample:	All	Regression	
	(1)	(2)	(3)
Post	-0.007***		
	(0.001)		
Post $\times$CEPI$^{[60,100]}$		-0.010	
		(0.010)	
Post $\times$CEPI$^{[70,100]}$			-0.011
			(0.010)
Post $\times$CEPI$^{[60,70)}$			-0.008
			(0.013)
Fixed effects:			
Firm	Yes	Yes	Yes
State $\times$ industry $\times$ year	No	Yes	Yes
Bandwidth	Yes	Yes	Yes
R^2	0.408	0.417	0.417
Observations	119,943	32,299	32,299

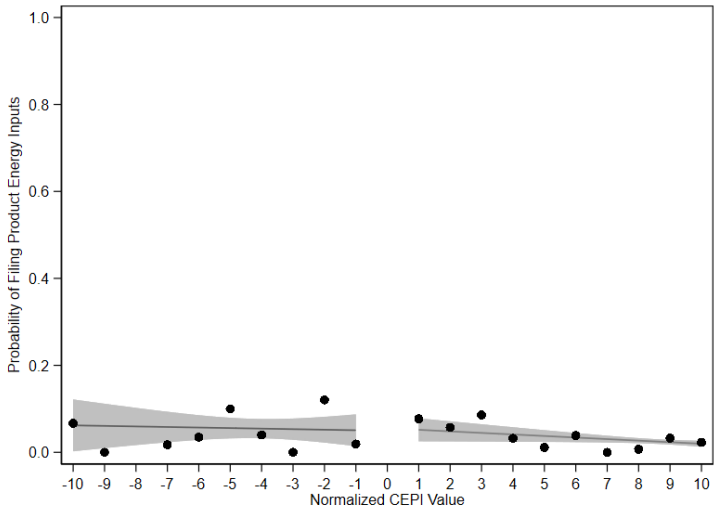


FIGURE IAG16: DISCONTINUITY IN THE PROBABILITY OF FILING PRODUCT ENERGY INPUTS AT BASELINE

This figure presents the average probability that a firm reports product-level energy inputs in its annual statement in 2008 around the CEPI treatment thresholds. We pool across a 10 CEPI-index value window around the two thresholds at CEPI 60 and 70, normalized in the figure to zero. A linear fit is generated separately for each side of 0, with the 95% confidence intervals displayed.

To our knowledge, this dataset offers unique access product-level energy inputs for such a large cross-section of firms. We exploit this unique data to bring new insight into how emission-capping regulations impact production decisions along the input dimension.

The data are at the firm-product-year-energy source level and are expressed in energy input units per reported production unit. For example, A.B.G. Cement Ltd. reported using 70.28 kWh of purchased electricity, 0.14 tonnes of coal, and 3.3 KWh of firm-produced electricity from a diesel generator per tonne of cement produced in 2014. Since regulators do not mandate a particular reporting standard, there exists variation in reporting units in the raw data. Therefore, we first separate the energy and production units and then standardize them. For example, we transform all production units reported in "lakh liters" into "liters" by using the fact that one lakh liter is 100,000 liters. Ultimately, we express all energy inputs in kcal per production unit. This conversion allows us to test for shifts in energy use across energy sources as a proportion of the total energy input in kcal.

Second, we transform energy input into CO_2 output. This exercise requires assumptions about each energy source's energy content and CO_2 output. We use the conversion factors and unit assumptions from the Central Electricity Authority (CEA) of India for 2008 (Central Electricity Authority, 2008), the year before the regulation. This choice fixes the energy technology just before the regulation. We assume that in the five-year window around the regulation, there are no drastic changes to technology that would change the CO_2 emissions of each fuel type significantly. Importantly, they are unlikely to change discontinuously around the thresholds set by CPCB.

Specifically, we use the CEA's assumptions on gross calorific value and CO_2 emission factors per fuel source that this regulator mandated that electricity plants use to quantify their CO_2 emissions in 2008 (Central Electricity Authority, 2008). We supplement this source from the 2008 *Commercial Energy Balance Tables and Conversion Factors* from the Energy and Resources Institute (Energy and Resources Institute, 2008). The latter gives us fuel-specific conversions between, e.g., mass units and volume units for the type of fuel used in Indian manufacturing firms. Table IAG10 reproduces the calculation inputs. Note that energy input from hydro, solar or wind sources are assumed to have zero CO_2 emissions.

Finally, we calculate tonnes of CO_2 emitted per reported production unit for each firm-product-year-energy source. Once all energy sources have the same units on the energy input side (kcal/production unit) and the CO_2 emissions side (tonnes of CO_2/production unit), we collapse the data to the firm-product-year level across energy sources.

Using the unique firm and product codes, we merge with our regression dataset of manufacturing firms, which contains the quantity produced of each product by each firm per reporting year. We next calculate the total CO_2 emissions per firm-product-year. So, in the end, we have a dataset at the firm-year-product level for the fiscal years

TABLE IAG10: PRODUCT-LEVEL ENERGY INPUTS TO CO_2 EMISSIONS

This table reports the assumptions we used when transforming product-level energy inputs into product CO_2 emissions. Note that we assume that CO_2 emissions from burning bio-waste are based on the idea of a closed carbon cycle —the carbon dioxide emitted when bio-waste is burned is offset by the carbon dioxide absorbed during the growth of the plants that produced the waste so that the amount of CO_2 released is approximately equal to the amount of CO_2 absorbed. Data source: Central Electricity Authority CO_2 Baseline Database 2008 (Central Electricity Authority, 2008) and the Commercial Energy Balance Tables and Conversion Factors from the Energy and Resources Institute (Energy and Resources Institute, 2008).

Fuel	Gross Calorific Value (kcal/kg)	Density (t/kls)	Fuel CO_2 Emission Factor	
			Electricity from Fuel (tCO_2/mWh)	Fuel (gCO_2/MJ)
Coal	3,755	0.95	1.04	90.6
Diesel	10,350	0.83	0.78	69.1
Oil	9,850	0.95	0.66	71.9
Gas	11,300	0.86	0.55	49.4
Lignite	3,000	0.83	1.28	100.5
Naptha	10,750	0.70	0.61	66.0
Bio*	3,625	N/A	0.00	0.0
Hydro	N/A	N/A	0.00	0.0
Solar	N/A	N/A	0.00	0.0
Wind	N/A	N/A	0.00	0.0
Nuclear	N/A	N/A	0.00	0.0

2005 to 2015 that tells us the total energy input per product reporting unit, the total CO_2 emissions and the CO_2 emissions per product reporting unit, and the proportion of the total energy from each fuel source. These data are summarized below for our regression sample in Table IAG11.

TABLE IAG11: SUMMARY STATISTICS: ENERGY INPUTS AND CO_2 EMISSIONS

This table presents descriptive statistics of the product energy inputs and CO_2 emissions for our baseline sample. *Ln(Total product energy input)* is defined as the natural logarithm of total product-level energy inputs for the firm-year. *Ln(Total product CO_2)* is defined as the natural logarithm of total product-level CO_2 emissions for the firm-year. *CO_2 per production unit* is defined as the ratio of total product in tonnes and the units the product is quoted in on the firm's annual statement. *Proportion purchased electricity* is defined as the ratio of the total product-level energy from purchased electricity and total product energy input.

	Obs	Mean	Std. dev.	Min	Median	Max.
	(1)	(2)	(3)	(4)	(5)	(6)
Ln(Total product energy input)	1,151	13.81	2.96	5.29	14.39	21.48
Ln(Total product CO_2 emissions)	1,151	4.37	4.45	-6.54	4.50	14.79
Tons of CO_2 per production unit	1,151	2.72	17.28	0.00	0.16	168.34
Proportion purchased electricity	1,151	0.56	0.47	0.00	0.99	1.00

Appendix H Probability of Filing Regulatory Data

What if results were driven by changes in firm filing patterns, either from concurrent reforms or the direct effect of the 2009 CEPI reform on firm filing behavior? In this Appendix, we test for this possibility.

First, in Table IAH12 we study a post-2011 change in product-level quantitative reporting requirements. The

Ministry of Corporate Affairs (MCA) revised Schedule VI of the Companies Act, 1956, effective for financial years beginning on or after April 1, 2011, removing mandatory product-wise quantity disclosures (e.g., installed capacity and production).[38] We estimate:

$$\Pr(Y_{ipt} = 1) \;=\; \alpha \;+\; \beta\,\mathbf{1}\{t \geq 2011\} \;+\; \gamma_{ip} \;+\; \varepsilon_{ipt},$$

where Y_{ipt} equals one if firm i reports production for product p in year t. The regression is restricted to firm-years in which the firm files at least one product entry, to remove the exit margin. $1(\text{Post } 2011)_t$ takes the value of one for fiscal years on and after 2011, and zero otherwise. γ_{ip} are firm-product fixed effects to estimate within products that the firm produced both before and after the reform.

Column 1 reports that the probability of reporting product-level production falls by about 8.6 p.p. after 2011. Column 2 repeats the test on the regression sample (multi-product manufacturing firms in the 88 clusters with a reported CEPI score in 2009) and finds a modest increase in the probability of filing of about 1.9 p.p.

TABLE IAH12: SELECTIVE REPORTING AT THE PRODUCT LEVEL AROUND INDIA'S 2011 REVISED SCHEDULE VI (COMPANIES ACT, 1956).

This table reports the change around the India's 2011 Revised Schedule VI to the Companies Act, 1956 in the probability that product-level production is reported, conditional on the firm filing at least one product entry that year. The unit of analysis is firm-product-year. Column 1 estimates on the full Prowess sample. Column 2 restricts to the regression sample: multi-product manufacturing firms in the 88 industrial clusters with a published CEPI score in 2009. *Post* is an indicator variable taking the value of 1 for all years from and including 2011. Estimation includes firm $\times$ product fixed effects. The standard errors are clustered at the firm level and are robust to heteroscedasticity. ***, **, * denote significance at the 1%, 5%, and 10% level, respectively. Data source: CMIE Prowess.

Dependent variable:	$\mathbb{1}_{\text{File Product Production}}$	
Sample:	All	Regression
	(1)	(2)
Post_{2011}	-0.086***	0.019***
	(0.004)	(0.006)
Firm $\times$ Product Fixed effects	Yes	Yes
R^2	0.561	0.727
Observations	269,088	46,844

But it still could be the case that firms' reporting behavior was itself impacted by the 2009 CEPI reform. For example, we might imagine that treated firms would be more likely to stop reporting firm-level energy inputs in an effort to under-report emissions. In Table IAH13 we test for this possibility. We use our main difference-in-discontinuities regression, described in Equation 1 in the main paper.

[38] See MCA Notification S.O. 447(E), Feb 28, 2011.

TABLE IAH13: PROBABILITY OF FILING ENERGY INPUTS

This table reports the effect of the 2009 CEPI emissions regulation on the probability of reporting product-level energy inputs in firm annual reports. The unit of analysis is firm-product-year. Model (1) is on all firms in the Prowess database. Models (2) and (3) are on the regression dataset comprising manufacturing firms in clusters with CEPI within a bandwidth of 10 pollution index units around the cutoffs at 70 and 60. *Post* is an indicator variable taking the value of 1 for all years including 2009 the year in which reform was implemented and after. $CEPI^{[70,100]}$ takes the value of one if the industrial cluster has a CEPI value at or above 70, and zero otherwise. $CEPI^{[60,70)}$ takes the value of one if the industrial cluster has a CEPI value greater than or equal to 60 and below 70, and zero otherwise. In specifications (2) and (3), the sample is restricted to the 88 industrial clusters targeted by the CPCB in 2009 with the omitted category including clusters with a CEPI value below 60 and includes firm and State × two-digit Industry × year fixed effects. The standard errors are clustered at the city level and are robust to heteroscedasticity. ***, **, * denote significance at the 1%, 5%, and 10% level, respectively. All variables are defined in Appendix Table IAB8. Data source: CMIE Prowess.

Dependent variable:	$\mathbb{1}_{\text{File Energy Inputs}}$		
Sample:	All	Regression	
	(1)	(2)	(3)
Post	-0.007***		
	(0.001)		
Post ×CEPI$^{[60,100]}$		-0.010	
		(0.010)	
Post ×CEPI$^{[70,100]}$			-0.011
			(0.010)
Post ×CEPI$^{[60,70)}$			-0.008
			(0.013)
Fixed effects:			
Firm	Yes	Yes	Yes
State × industry × year	No	Yes	Yes
Bandwidth	Yes	Yes	Yes
R^2	0.408	0.417	0.417
Observations	119,943	32,299	32,299

We again see in column 1 that firms are significantly less likely to report energy use after the reform than otherwise similar control firms. However, in columns 2 and 3, which run the same specification on the regression sample, we see no significant difference in filing probability. Overall, along with the null effect of the reform on product-level production quantities reported in the main paper, these tests alleviate the concern that our results are driven by selective failure to report for high-emission products.

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