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When do Firms Go Green? Comparing Price Incentives with Command and Control Regulations in India
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ABSTRACT

India has a multitude of environmental regulations but a history of poor enforcement. Between 1996 and 2004, India's Supreme Court required 17 cities to enact Action Plans to reduce air pollution through a variety of command-and-control (CAC) environmental regulations. We compare the impacts of these regulations with the impact of changes in coal prices on establishment-level pollution abatement, coal consumption, and productivity growth. We find that higher coal prices reduced coal use within establishments, with price elasticities similar to those found in the US. In addition, higher coal prices are associated with lower pollution emissions at the district level. CAC regulations did not affect within-establishment pollution control investment or coal use, but did impact the extensive margin, increasing the share of large establishments investing in pollution control and reducing the entry of new establishments. For reducing SO2 emissions, our results suggest that higher coal prices were more effective in improving environmental outcomes than command and control measures.

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1 Introduction

New Delhi is the most polluted city on earth, with levels of harmful particulate matter that are far higher than those found in Beijing. In 2014, the WHO estimated that 13 of the 20 cities in the world with the highest levels of air pollution were in India.[2] These high levels of air pollution are due to a number of factors, including vehicular emissions, burning of fossil fuels, and economic expansion. The 2014 World Energy Outlook projects that India will overtake the US as the world's second largest coal consumer before 2020, and will also surpass China as the world's biggest coal importer (IEA, 2014).

Indian lawmakers have passed hundreds of pieces of environmental legislation at the state, national, and municipal level to address rising pollution. Most of this environmental legislation has taken the form of command-and-control (CAC) directives which impose specific requirements on automobiles, factories, or power plants. A long-standing view among economists suggests that market-based instruments may be more effective at addressing pollution than these CAC regulations. Higher prices for coal or carbon taxes could lower the cost per unit of emissions reduction, which provides incentives to innovate. When institutions are weak or enforcement is a problem, higher prices for fossil fuels or higher carbon taxes could in theory have an even greater impact on firm behavior than CAC initiatives. This is because price mechanisms are typically easier to implement and depend less than CAC on institutional ability to enforce regulations.

India has introduced a wide range of environmental regulations but has relatively weak institutions (Bertrand et al. (2007), Duflo et al. (2013), Duflo et al. (2014), Greenstone and Hanna (2014)). In 1991 the Ministry of Environment and Forests (MoEF) identified 17 "Category H" or highly-polluting industries (HPI) as particularly worthy of regulation. Since then, the Central Pollution Control Board (CPCB) and the State Pollution Control Boards (SPCBs) have together targeted these HPI industries through a variety of CAC directives for air and water emissions and waste disposal. In 1996, India's Supreme Court embarked on an effort to reduce pollution which over the following 8 years required 17 cities to enact Action Plans aimed at reducing air pollution through a variety of CAC regulations.

[2] World Health Organization, Ambient (Outdoor) Air Pollution Database, v4, July 18, 2014.

HPI industries featured prominently as regulatory targets in these Action Plans.

In this paper, we compare the impact of these command-and-control policies with coal price changes on the behavior of Indian manufacturing firms. To our knowledge this is the first attempt to analyze the effectiveness of environmental legislation on a comprehensive dataset of Indian establishments.[3] We are able to identify the role of price mechanisms in reducing coal consumption because of geographic variation in coal prices. That variation is driven by establishment distances from coal deposits within India as well as state level differences in supply policies for coal. We use a nationally representative establishment-level panel dataset from India's Annual Survey of Industries (ASI) over the period between 2000 and 2009 to estimate the impacts of the Action Plans versus price signals on establishment-level pollution abatement investments and coal consumption. One approach we do not evaluate – as it was not used, to our knowledge, by the Indian government during our sample period – is the explicit use of price mechanisms like a carbon tax on dirty fuels.[4]

Our study builds on recent work by Greenstone and Hanna (2014), who collected detailed information on the timing and location of the Action Plans and merged them with district level emissions data. They also compared the impact of Action Plans with other measures to address water pollution and explicit policies which encouraged the use of catalytic converters for vehicles. Greenstone and Hanna (2014) find that the most effective of these CAC plans was the legislation for reducing air pollution through the mandated adoption of catalytic converters by vehicles.

Greenstone and Hanna (2014) do not evaluate establishment level responses to the Action Plans. While the focus of their study is on vehicular emissions, much of the legislation has sought to directly change the activities of polluting firms and industrial sectors. The indirect evidence in Greenstone and Hanna (2014) points to a limited impact on firm behavior. In this paper, we are able to directly evaluate the effectiveness of the Action Plans on firm behavior. One potential explanation for the limited impact of the Action Plans as documented by

[3]The Action Plans and HPI initiatives comprise two of India's largest efforts to curb emissions in the country's regulatory history. To our knowledge, this paper is also the first to use nationally representative micro-data to estimate the cost-side of CAC regulations in a large emerging market setting.

[4]In an effort to generate a National Clean Energy Fund, the Indian government did begin to tax coal in 2010 – at roughly $0.83 (50 Rs.) per metric ton of coal, doubling the tax to $1.67 (100 Rs.) per metric ton of coal in 2014.

Greenstone and Hanna (2014) is that firms simply failed to respond – a hypothesis we explore in our research. Another possibility is that CAC policies are simply not effective tools in stimulating enterprise behavior in a large and complex emerging market.

While the ASI data permit us to directly test the impact of Action Plans on establishment-level behavior, we also complement the Greenstone and Hanna (2014) study with an in-depth examination of the interaction of the Action Plans with another set of regulatory instruments: legislation targeted at Highly Polluting Industries (HPI). Unlike the Action Plans, which were mandated by the Supreme Court at specific points in time, the regulation of HPI has taken place through a multitude of regulations covering emissions to water, air and land by one or more of these industries, developed over decades. Many of the Action Plans themselves targeted HPI specifically; even in those areas where the Action Plans did not explicitly target HPI, it is possible that the impacts on HPI were greater due to the nature of the industries or the fact that they had already been regulated. We thus explore whether the effect of the Action Plans differed for establishments operating in HPI versus non-HPI industries.

Our results add to a large public finance literature contrasting price instruments with quantity controls. The majority of these studies find evidence that using emissions fees, permits, or input taxes to equate the marginal costs of abatement with the marginal social cost of pollution damage are the most effective and least costly ways to abate pollution. (See Bohm and Russell (1985) for an overview and Harrington and Morgenstern (2007) for a discussion contrasting US and EU experiences.)[5]

Theory suggests that economic instruments out-perform CAC policies in an environment with few, if any, market distortions. In developing countries, these distortions can be particularly large. Laffont (2005) and Estache and Wren-Lewis (2009) argue that optimal regulation is likely to look different in developing countries as a result of limited regulatory capacity, limited accountability, limited commitment, and limited fiscal efficiency. Blackman

[5] Cap-and-trade schemes have been shown to be especially effective market instruments toward this end. Ellerman (2003) evaluates the SO2 cap-and-trade system created by the 1990 Clean Air Act Amendments (i.e. the Acid Rain Program), and shows that realized costs under cap-and-trade were one quarter of the estimated cost of CAC standards. Fowlie et al. (2012) further show that average emissions at NOx Reclaim facilities fell 20% relative to similar facilities subject to CAC regulations, and Jaffe and Stavens (1995) show that CAC regulations can fail to provide incentives for R&D in new abatement technologies, unlike market-based instruments.

and Harrington (2000) describe the difficulty enforcing environmental regulation in a developing country context, adding factors such as high monitoring costs due to the large number of very small firms, limited data collection, and low demand for strict policies or voluntary measures on the part of voters or consumers. India is not exempt: Duflo et al. (2013) reveal high levels of corruption in India's system of environmental audits.

One solution to high monitoring costs may be to concentrate efforts on policies that directly affect factor prices. For example, taxing pesticides production can be more effective than monitoring pesticide use by individual farmers, especially if the human cost of pesticide application does not vary widely across the region in question. Khanna and Zilberman (2001) show that eliminating domestic and trade policy distortions has the potential to reduce carbon emissions by inducing the adoption of energy efficient technologies by changing relative fuel prices. Specifically, they show that removing trade restrictions reduced the price of cleaner coal in India, leading manufacturing firms to switch fuels.

Our results suggest that the Action Plans had little impact on within-establishment pollution abatement or coal use. However, the Action Plans did increase the number of large, HPI establishments investing in pollution abatement, but decreased pollution abatement investments among small, non-HPI establishments. Given that large, HPI establishments are the most likely to be required to install pollution abatement equipment, it appears that the Action Plans may have caused regulators to focus even more strongly on this group of establishments, potentially allowing backsliding among other establishments.

The Action Plans, although in many cases specifically targeted at the use of dirty fuels, did not affect coal use. In contrast, higher coal prices had significant impacts on establishments. Higher prices are associated with significantly lower consumption in terms of tons of coal and intensity of coal use. The price elasticity is in line with US estimates: a 10 percent increase in the price of a ton of coal leads to an approximately 5.8 to 10 percent reduction of tons of coal consumed.

We then examine the impact of CAC versus price mechanisms on several non-environmental outcomes, namely total factor productivity (TFP), entry and exit. A number of developing country policy makers have expressed concerns that environmental mandates imposed by industrial countries could prove particularly costly in terms of foregone growth and competitiveness if applied in developing countries. In contrast, supporters of environmental legislation point to a "double dividend" from abatement investment, suggesting that legislation to improve environmental outcomes can also foster innovation and productivity growth. A related literature on price-induced technological change, first proposed by Hicks in 1932, suggests that high energy prices can lead to both adoption of cleaner technologies and positive R&D spillovers. This induced innovation has been shown to decrease energy demand of new entrants (Linn (2008)), affect the mix of durables offered by the firm (Newell et al. (1999)), and to increase energy-related patents (Popp (2015)).

The Porter Hypothesis is an extension of this idea, arguing in its strictest interpretation that environmental regulation can benefit firms. Porter posits that regulations can increase productivity due, say, to positive spillovers from R&D or first-mover advantages relative to unregulated firms. There is limited empirical support for a *strong* Porter Hypothesis.[6] Instead, evidence suggests that regulated firms experience foregone earnings (Walker (2012)), TFP decreases (Greenstone et al. (2012)), and less entry / higher exit in response to regulations (Becker and Henderson (2000) and List et al. (2003)). In a developing country however, there may be evidence of a strong Porter Hypothesis. Tanaka et al. (2014) find evidence that SO2 and acid rain regulation *increased* industrial productivity in China due to both selection effects (entry of more efficient and exit of less efficient firms) and within-firm adoption of cleaner technologies. Liu and Martin (2014) evaluate a large industrial energy efficiency program in China and show that the difference in productivity growth rates between participating and counterfactual non-participating firms is very small (less than 1%), despite evidence of positive air quality impacts.

We find that between 2000 and 2009, Indian manufacturing establishments steadily increased TFP, as exhibited by a positive time-trend coefficient. However, the introduction of Action Plan legislation reversed that trend, partially offsetting the TFP increases in Action Plan districts. We find that small, non-HPI establishments experienced an increase in TFP after the Action Plans are implemented, which may be partially due to their observed divestment of pollution control equipment. Higher coal prices are correlated with slightly

[6] There is ample evidence, on the other hand, of the weak Porter Hypothesis, namely, that environmental regulation stimulates environmental innovations. See the above studies and Jaffe and Palmer (1997).

lower productivity. Our results point to a robust, negative impact of CAC measures on establishment productivity, but a less robust negative impact of higher coal prices.

We conclude by examining the consequences for district-level air pollution emissions. Using comprehensive emissions data collected by Greenstone and Hanna (2014) and supplemented with additional reports from India's The Energy and Resources Institute (TERI), we find that higher coal prices have been more effective in reducing sulfur dioxide (SO2) emissions than command-and-control policies enacted through Supreme Court Action Plans. Like Greenstone and Hanna (2014), though, we find that the Action Plans do appear to have reversed the increasing trend in NO2 emissions.

This paper is organized as follows. Section 2 describes the different environmental policies we study. Section 3 describes the data, while Section 4 discusses identification issues. Section 5 presents the results and Section 6 concludes.

2 Policy Background

We focus on two sets of CAC policies: policies introduced in 1991 designating High Polluting Industries (HPI), and Supreme Court Action Plans (SCAP), introduced in 1996. The SCAP also interacted with the earlier HPI designations by explicitly focusing on HPI sectors in many cases.

In 1991 the MoEF identified 17 HPI which were further monitored at both the central government and state government levels. In certain cases, new standards were imposed on specific industries from the HPI list (for example, stricter PM standards for small cast iron foundries in Lucknow); in several instances, cities adopted the "Corporate Responsibility for Environmental Protection" (CREP) charter for HPI. This charter was established by MoEF and CPCB in 2003, and set specific new standards for the 17 HPI.

The Supreme Court of India, partly in response to perceptions of inadequate action by government ministries, ordered Action Plans to be developed, submitted, and implemented in seventeen cities, starting in 1996 with the national capital. Subsequently, a number of Action Plans also specifically targeted the 17 HPI industries as designated in 1991.

The Supreme Court Action Plans typically targeted vehicular pollution and also imposed a variety of restrictions on manufacturing firms, including requirements to use cleaner fuels, to close or relocate polluting factories, and to install pollution control equipment. Earlier work suggests that the Action Plans may have reduced nitrogen dioxide (NO_2) pollution slightly, but had no impact on suspended particulate matter (SPM) or sulfur dioxide (SO_2); in contrast, a policy requiring catalytic converters was linked with a reduction in PM and SO_2 (Greenstone and Hanna, 2014).

This short section cannot do justice to the extensive set of policies enacted at different central, state, and municipal levels to address growing pollution problems in India. We have omitted a discussion of some policies either because they are not easily quantified or because their enactment falls outside the scope of our time period. For example, one of the first attempts to address pollution were the Problem Area Action Plans (PAAPs). These were comprehensive plans targeting industrial pollution in 26 different cities, implemented by the CPCB and the state-level branches. However, these PAAPs were first identified in 1990, when 16 areas were designated as problem areas, then again in 1995 (an additional six) and in 1996 (4 more). While likely important, there is no evidence to date that these PAAPs were enforced by the Supreme Court or funded by the CPCB or the development banks. Since these designations were made before our sample begins, we have chosen to subsume their probable outcomes into fixed effects in our baseline specifications. However, we have also explored specifications in which we interact PAAP designation with SCAP designation, and we find broadly similar effects of the SCAP in areas that were previously designated as PAAP and those that were not.

Another key policy outside of the scope of our time frame and analysis was the introduction in 1994 of the National Ambient Air Quality Standards (NAAQS). These standards, formulated by the CPCB, introduced benchmarks for seven pollutants. The policy also provided guidelines for calculating exceedence factors regarding ambient air quality, which are regularly published. The NAAQS appear to primarily play the role of identifying, monitoring, and reporting on pollution levels. There are no rules for monitoring compliance or imposing penalties. Exceedence Factors continue to be published annually by the CPCB, and in 2009, a new Comprehensive Environmental Pollution Index (CEPI) was used for the first time to red-flag 43 non-attainment areas as Critically Polluted Industrial Clusters for subsequent intervention. However, we do not have ample post-data to analyze effects of the CEPI.

3 Data

3.1 Establishment-Level Data

We use 10 years of establishment-level panel data (2000 through 2009) from the Annual Survey of Industries (ASI), comprising 89,946 unique factories after sample restrictions. The ASI data are, for the most part, at the level of the establishment or factory; owners of multiple factories in the same state and industry are allowed to furnish a joint return, but fewer than 5 percent of observations in our sample report multiple factories. Thus, all of our analyses should be interpreted as being at the establishment rather than the firm level.

The ASI panel includes 9 years of data on pollution control investment, pollution control capital stock, and expenditures on repair and maintenance of pollution control stock (2001 through 2009). Note that, as defined, pollution control represents undifferentiated investments to address air pollution, water pollution and/or hazardous waste. We use reported pollution control investment to calculate pollution control stock according to a perpetual inventory method.[7]

For each establishment we also observe annual expenditures on fuels, including expenditures on coal, petrol / diesel, and electricity, as well as quantities of coal consumed, and quantities of electricity consumed, generated and sold. We use these data to construct several outcome measures that we expect to be closely linked to the environmental policies we study: the stock of pollution control assets, fraction of pollution control assets in total capital stock, coal use in tons, and intensity of coal use (tons of coal use per rupee of output). We also draw on the establishment-level data to calculate total factor productivity (TFP) via the following methods: Solow Residual, Index Method (following Aw, Chen, and Roberts (2001)), Olley

[7] We take the first year an opening pollution stock value is observed, and add within-year pollution investments plus the year-to-year change in pollution stock taken from comparing the jump between closing and opening pollution stock values across years to attain a new value for investment. We then add this (deflated) investment to the previous year's opening stock, and depreciate the new closing value by 10%, repeating for subsequent years.

and Pakes (1996), and Levinsohn and Petrin (2003).[8] Output values are deflated using the appropriate industry-specific wholesale price index (WPI). We have detailed product-level price and quantity data for primary outputs and inputs, which allows us to calculate material input deflators by weighting commodity-specific WPI by commodity-specific input shares.[9] Investment in machinery, transport equipment and computer systems are deflated separately by commodity-specific WPI, while fuel inputs are deflated by the fuel-specific WPI. Wages (used in estimating TFP) are deflated using the consumer price index (CPI).

Establishment location is identified at the district-area level, with 605 unique districts and two areas within each district (urban and rural). The ASI panel does not contain district-level identifiers, but the cross-sectional data do. We are the first researchers to have purchased and merged both cross-section and panel datasets to integrate district identifiers into the ASI panel.[10] We also know the primary industry in which an establishment operates at the 5-digit level, representing 476 unique 5-digit industries. We use this industry information to construct a dummy variable indicating whether an establishment has ever operated in an HPI industry.[11]

3.2 Policy Data

Action Plans

The Supreme Court Action Plans were implemented at the city level, which we match to districts from our establishment-level dataset (Table 1). Several Action Plans were implemented in cities spanning multiple districts; in these cases we assume the Action Plans affected all of the districts. We observe establishments before and after the implementation

[8] For a more detailed discussion of the methodology used to calculate TFP, see Harrison, Martin, and Nataraj (2013).

[9] We use input shares from 2001 to avoid potentially endogenous changes in input mix due to the policies we study.

[10] District level identifiers were not available for 2009, and were instead imputed from previous panel data. Our results however, are robust to re-running the entire analysis omitting 2009.

[11] A number of establishments do appear to move into and out of operation in HPI industries. However, this largely appears to be a function of small changes in product mix. For example, if an establishment reports a primary industry of "casting of iron and steel" in a particular year and "casting of non-ferrous metals" in the following year, it would be classified as an HPI in the first year but not the in second, even though the change in category likely reflects a change in product mix rather than a substantial shift in industry or applicable regulations.

of 16 of the 17 Action Plans. Delhi was mandated to develop an Action Plan in 1998, prior to the sample period. Therefore we exclude Delhi from our analysis.

Figure 1 shows the geographic distribution of Action Plans overlaid on top of districts, which are coded according to the total number of pollution monitors (SPM, NO2, SO2) ever active in each district. The map shows significant coverage of Action Plan districts by pollution monitors. Furthermore, Figure 1 reveals that the 11 Action Plans implemented in 2003 were concentrated in the northern region of the country, while the 5 Action Plans mandated in 2004 were concentrated in southern India. [12]

Examining hard-copy Central Pollution Control Board (CPCB) reports, as well as a report on air quality trends and action plans in 17 cities by the MoEF and CPCB, suggests that the Action Plans likely targeted a variety of industries through different means. Examples of action items include closure of clandestine units (Faridabad), moving various industries and commercial activities outside of city limits (Jodhpur, Kanpur), installation of electrostatic precipitators in all boilers in power generation stations (Lucknow), surprise inspections (Patna), and promotion of alternative fuels in generators (Hyderabad).

Many of the directives issued through the Action Plans targeted the extensive margin of establishment activities. In other words, these directives encouraged establishments to either exit the industry, relocate, or to invest in activities (like scrubbers) when they had previously not addressed the need to abate pollution at all. Out of a total of 17 city-level action items we surveyed, 15 of these 17 had direct mention of pollution control equipment, while 14 out of 17 had direct mention of relocation, exit, or closure. A much smaller share of Action Plan activities appear to focus behavior at the intensive margin, such as encouraging more investment by establishments that already engaged in abatement activities. This is an important characteristic of Action Plan mandates as we turn to their effects on manufacturing establishments.

Highly Polluting Industries

A number of Action Plans also specifically applied to the 17 industries identified by

[12] As noted above, Problem Area Action Plans (PAAPs) were also targeted geographically. However, since PAAPs were mandated in 1989, we do not identify policy variation within our sample period and have thus omitted them from the map.

the CPCB as "Highly Polluting" (HPI). These industries are: aluminum smelting; basic drugs and pharmaceuticals; caustic soda; cement; copper smelting; dyes and intermediates; fermentation (distillery); fertilizers; integrated iron and steel; leather processing; oil refining; pesticides; pulp and paper; petrochemicals; sugar; thermal power plants; and zinc smelting. We manually match all of these HPI, with the exception of "Thermal power plants",[13] to 97 5-digit NIC industries. As discussed above, we then identify HPI establishments as those that ever reported a primary industry code that was matched to an HPI.

3.3 Coal Prices

The Action Plans can be seen as examples of CAC regulation. Establishments may also respond to changing coal prices through measures that increase efficiency and reduce coal use. However, establishment-level coal prices are likely to be endogenous to establishment-specific characteristics; for example, larger establishments may command more market power and thus face lower prices. We have two strategies for circumventing price endogeneity concerns. First, in base specifications we measure the coal price faced by an establishment as the mean coal price in the establishment's district, excluding the establishment's own price.[14] This price measure is flexible in that in does not constrain estimation to the subset of establishments with non-missing coal prices. Second, in our preferred specification we use a variant of the Hausman (1996) instrumental variable as a plausibly exogenous cost-shifter of a firm's coal input price when estimating coal price elasticities. As is common in the industrial organization literature, we use the mean input prices faced by similar firms in other markets that do not directly affect own-firm demand. Following extensive exploration of the determinants of coal price variation in our data (described in the appendix), we define our IV as the log mean price faced by firms within the same 2-digit industry and state.[15]

[13]As power plants are outside the scope of the ASI's coverage of manufacturing sectors, we could not analyze thermal plants in our main specifications. We were however, able to locate thermal power plant coal use data from India's Central Electric Authority's Thermal Performance Reviews – an important control variable for our emissions specifications. However, this dataset does not contain the dependent variables that would permit their inclusion in the main analysis.

[14]If fewer than 10 establishments report coal use (and thus coal prices) in a particular district and year, we assign coal users the mean state-level coal price (excluding own price).

[15]Defining the IV within industry-state-year cells also has the added advantage that coal quality differences across industries are controlled for.

3.4 Air Pollution Data

In this paper, we focus on estimates of SO2, NO2, and SPM to compare the impact of Action Plans with the effects of coal prices on environmental outcomes. SPM, or suspended particulate matter, captures general pollution levels. The CPCB website indicates that "RSPM levels exceed prescribed NAAQS in residential areas of many cities....The reason for high particulate matter levels may be vehicles, engine gensets, small scale industries, biomass incineration, resuspension of traffic dust, commercial and domestic use of fuels, etc."[16]

SO2 levels are primarily attributable to burning of fossil fuels. In recent years, the the CPCB indicates that in India's SO2 levels have been declining in major cities, in part because of efforts to introduce cleaner fuels and new norms for vehicles and fuel quality. There have also been efforts to shift domestic fuel use away from coal. In our paper, the comparison of Action Plan measures with coal price effects is most likely to be relevant for SO2 levels, as they are most closely linked to fossil fuel use. NO2 levels are generally attributable to vehicular exhaust and as such a reduction should be associated with efforts to reduce pollution associated with vehicle exhaust. The CPCB's website indicates that "NO2 levels are within the prescribed National Ambient Air Quality Standards in residential areas of most of the cities. The reasons for low levels of NO2 may be various measures taken such as banning of old vehicles, better traffic management etc."

Our air pollution data are based on city-level data provided by Greenstone and Hanna (2014) for 2000-2007. We supplement their data with additional observations from The Energy and Resources Institute (TERI) in its TERI Energy Data Directory Yearbook (TEDDY) for 2008.[17] Figure 1 shows the locations of air quality monitors. Air quality data are only available for a subset of cities; we mapped each city for which the data are available to the corresponding district(s) in our dataset.

[16] Website accessed on June 1, 2015 at http://cpcb.nic.in/Findings.php.

[17] Results are robust to using the pollutant data from TERI / TEDDY for all years.

3.5 Summary Statistics and Trends

In Table 2, we present summary statistics for our main variables, after implementing our preferred sample restrictions.[18] Variable means and standard deviations are broken out by six key analysis groups: whether or not an establishment was ever regulated by an Action Plan (SCAP, NotSCAP), whether or not an establishment ever listed an HPI as its primary industry, and establishment size (Large versus NotLarge, which indicates whether the establishment had above or below 100 laborers—the threshold most commonly used by Indian regulators targeting large establishments—in the initial year in which it was observed).

HPI establishments are on average larger in size (in terms of capital stock as well as employment), and have a higher average level of pollution control capital stock than their non-HPI counterparts. HPI establishments have a 14 percentage point higher probability of ever using pollution control equipment, over a base of 7.5% for non-HPI establishments. HPI establishments also have a higher probability of coal use: 16.2 % of HPI establishments report ever using coal, compared to 10.2% for others.

Establishments in all groups face similar coal prices, entry and exit rates, and productivity levels. Establishments in districts that are ultimately treated by Action Plans have lower observed values of pollution control stock and coal use variables, on both the intensive and extensive margin.

For example, establishments in Action Plan districts have a 4 percentage point lower coal use probability than establishments in non-SCAP districts, and have substantially lower average coal use in terms of tons and coal intensity rate as measured by the coal tons used per unit of output. Establishments in Action Plan districts also have a lower overall probability of using pollution control equipment. 11.5% of non-SCAP establishments report ever having used pollution control equipment, compared to 9.2% for SCAP-exposed establishments.

Columns (5) and (6) show some significant differences between large and small enterprises. Large enterprises are much more likely to report positive pollution abatement investment,

[18] As discussed in the next section, while the event years of the analysis run from -4 to +6, we restrict our study to the window from -3 to +5 such that no single policy exerts leverage over the stacked results. This is analogous to imposing a balanced panel requirement for Action Plan-treated districts in event time. We also drop the Delhi Action plan as our panel currently does not accommodate any data prior to 1998, the year in which Delhi was mandated to adopt an Action Plan by the Indian Supreme Court.

with 21.8 % of large enterprises reporting positive investment at some point but only 5.7% of small establishments doing so. While these two groups report a similar probability of coal use and face similar coal prices, large establishments have somewhat higher entry rates and lower exit rates.

Figure 2 shows trends in the fraction of establishments reporting positive pollution control stock and positive coal use. The top two panels of Figure 2 show the fraction of establishments reporting any pollution control stock, and any coal use, respectively, for HPI versus non-HPI establishments. In line with the long history of regulation of HPI sectors, establishments in HPI industries are more likely to have pollution control assets than establishments in non-HPI industries. The top left panel also offers a preview of some of our results: prior to the implementation of the Action Plans, about 15 percent of HPI establishments had non-zero pollution control stocks, against 5 percent of non-HPI establishments. Following the enactment of the Action Plans, the fraction of non-HPI establishments with non-zero pollution control stock continues its steady climb, while the fraction of HPI establishments with pollution-control stock rises more quickly than before.

The top right panel also confirms expectations that HPI establishments are more likely to use coal than non-HPI establishments. Over time, the fraction of establishments using coal has generally fallen, in both HPI and non-HPI industries. However, both types of establishments - and in particular HPI establishments - exhibit an uptick in the probability of coal usage during the late 2000s.

The preliminary evidence in these figures suggests that there was more significant movement for sectors labelled as HPI sectors than for the rest of the economy. While the trends are consistent with some impact on HPI sectors following the passage of the Action Plans, visually the evidence is suggestive but clearly not conclusive. In the empirical section of this paper, we test for an interaction between Action Plan passage and designation as an HPI sector.

The bottom two panels compare trends for districts that implemented Action Plans and those that did not. The bottom left panel suggests that in 2001 and 2002, the fraction of establishments investing in pollution control stock was slightly lower in districts that would eventually implement Action Plans. The non-Action Plan districts show a slight upward trend starting in 2003, while the Action Plan districts show an upward trend beginning in 2004. The lower right panel suggests that Action Plan districts had a lower fraction of establishments reporting coal use, and that the fractions have fallen in all districts over time. Taken together, there is no clear visual evidence across all four panels that Action Plans had a strong impact on establishment performance, either by encouraging more pollution abatement investments or by reducing coal use. There is some evidence, however, that Action Plans combined with HPI status may have changed establishment behavior.

4 Identification Strategy

Our identification strategy exploits the differential incidence and timing of the Action Plans. The Action Plans were mandated for certain cities by the Supreme Court, and (with the exception of Delhi) implemented in 2003 and 2004. We compare districts that implemented an Action Plan against those that did not, and we separately examine effects on establishments in HPI versus non-HPI industries.

We use a "stacked" difference-in-differences (DID) method following Greenstone and Hanna (2014) where we estimate the following for establishment i in district d in year t:[19]

$$y_{idt} = \beta_1 SCAP_{d\tau} + \lambda CoalPrice_{idt} + \alpha_i + \eta_t + \epsilon_{idt} \tag{1}$$

The variable SCAP is equal to 1 in a district that receives an Action Plan, in any year after the Action Plan is in place, 0 otherwise; τ denotes event time. The coal price is equal to the mean district price, excluding own price, and hence varies at the establishment level. Except when noted, our specifications include establishment fixed effects α_i as well as accounting year fixed effects η_t.

We begin by examining the impacts of the Action Plans and coal prices on the probability that an establishment reports any pollution control stock, or that it uses coal. In these cases, we implement linear probability models, where the outcome of interest y_{idt} is a dummy equal

[19]While event years run from -4 to +6, we restrict our analysis to the window from -3 to +5 such that no single policy exerts leverage over the stacked results. This is analogous to imposing a balanced panel requirement for Action Plan-treated districts in event time.

to one if the establishment reports a positive value of pollution control stock (coal use), zero otherwise.

We then consider whether the policies and prices had any impact on within-establishment changes in coal use or pollution control stock. The specific outcomes we examine are: pollution control stock (estimated using a perpetual inventory method as described above), fraction of total capital stock invested in pollution control, coal use in tons, and coal intensity of output (tons of coal per unit of real output).

Our outcomes of interest also include three non-environmental aspects of establishment behavior: TFP, entry and exit. The entry variable takes on a value of 1 in the first year an establishment appears in the data within three years of the observed initial production date.[20] The exit variable takes on a value of 1 in the year an establishment is officially declared "closed" in the ASI, so long as it remains closed thereafter.

We also estimate the effects of the Action Plans and coal prices on the probability of establishment entry and exit using linear probability models. In these cases, we use a similar specification as above, but exclude establishment fixed effects in order to identify the effect based on all establishments, not just entrants and exiters.

Since the Action Plans were mandated by the Supreme Court, we need not be concerned about the endogeneity of an individual city's decision to adopt a plan. The DID strategy also accounts for any time-invariant differences across Action Plan and non-Action Plan cities. However, as noted by Greenstone and Hanna (2014), we might be concerned about a correlation between the Supreme Court's mandate for an Action Plan, and pre-existing *trends* in the outcomes of interest. We thus present specifications that also control for a linear time trend (τ) in event time. The time trend (τ) is normalized to zero for any district which is never mandated to adopt an Action Plan over the sample period. In addition, we interact the time trend with the Action Plan dummy to examine whether the effect of the policy changes over time:

$$y_{idt} = \beta_1 SCAP_{d\tau} + \beta_2 \tau + \beta_3 SCAP_{d\tau} \times \tau + \lambda CoalPrice_{idt} + \alpha_i + \eta_t + \epsilon_{idt} \tag{2}$$

[20] We do not ascribe an entry value of 1 if the factory was left-censored, and chose the threshold value 3 based on the mean difference between the reported date of initial production and the establishment's first appearance in the survey data.

As noted above, many of the Action Plans specifically targeted HPI. We might also expect effects to differ for HPI and non-HPI industries simply because the HPI industries have historically been major polluters, and have been regulated more heavily. In addition, like many other countries, India tends to focus its environmental regulations on larger establishments. Thus, we examine whether the Action Plans had differential impacts for establishments in HPI versus non-HPI industries, and for large and small establishments:

$$
\begin{aligned}
y_{idt} = {} & \beta_1 SCAP_{d\tau} + \beta_2 \tau + \beta_3 SCAP_{d\tau} \times \tau + \delta_1 SCAP_{d\tau} \times HPI_{idt} \times Large_{idt} \\
& + \delta_2 SCAP_{d\tau} \times HPI_{idt} \times NotLarge_{idt} + \delta_3 SCAP_{d\tau} \times NotHPI_{idt} \times Large_{idt} + \\
& \delta_4 SCAP_{d\tau} \times NotHPI_{idt} \times NotLarge_{idt} + \lambda CoalPrice_{idt} + \alpha_i + \eta_t + \epsilon_{idt}
\end{aligned} \quad (3)
$$

HPI is a dummy equal to 1 if the establishment ever reported its primary industry as one that is flagged as highly polluting, 0 otherwise. To avoid the potential endogenous reaction of establishment size to the Action Plans, we define an establishment as "large" if its real capital stock is above the median in the first year in which we observed it. The establishment fixed effects absorb the direct effects of the HPI and establishment size variables.

Finally, we conduct similar regressions at the district level to examine the effects on district-level pollution measures:

$$
y_{dt} = \beta_1 SCAP_{d\tau} + \beta_2 \tau + \beta_3 SCAP_{d\tau} \times \tau + \lambda CoalPrice_{dt} + \alpha_d + \eta_t + \epsilon_{dt} \quad (4)
$$

In this set of specifications, we also control for coal use by thermal coal power plants, which account for approximately three-quarters of India's coal use.[21]

For establishment-level results, we apply sampling multipliers in our analyses. For district-level results, we first aggregate the establishment-level data to the district level using sampling multipliers; we then present results in which each district has equal weight, and in which each district is weighted by the initial number of establishments in the district.

[21] The ASI establishment-level data however, unfortunately do not cover electricity units. Consequently, we cannot include them in our main specifications as we do not observe any of the main variables of the analysis for thermal coal plants.

In all cases, standard errors are clustered at the district level.

5 Results

We begin by exploring the overall impact of Action Plans and coal prices on the probability that an establishment reports a positive value for pollution control stock or coal use. This is what we refer to as the "extensive margin". Columns (1) and (3) of Table 3 report the results from estimating Equation 1 for pollution control stock and coal use, respectively, and show that overall, the Action Plans had no substantial impact on the probability that an establishment had pollution control equipment or used coal.[22]

Columns (2) and (4) introduce a control for a linear time trend and an interaction between the time trend and the Action Plans as in Equation 2. The coefficient on the time trend confirms the visual evidence in Figure 2 that coal use has been declining over time. Columns (3) and (4) also show little relationship between coal prices and the probability of any coal use. Overall, we see no clear relationship between Action Plan legislation and two primary measures of environmental responses at the establishment level: investment in pollution abatement and reduction in the use of dirty fuels. We now explore whether heterogeneity in responses for establishments of different sizes and sectors could obscure significant impacts of the Action Plans on establishments. As we saw, establishments in HPI sectors were targeted through the Action Plans and are likely to have received special treatment and additional scrutiny.

In Table 4 we explore whether Action Plans affected the probability of coal use or pollution abatement investment for different size establishments and HPI designation. While the Action Plans were not associated with an overall change in whether or not establishments invested in pollution control (the extensive margin of establishment behavior), column (1) shows that Action Plans are associated with a significant increase in the probability that large establishments in HPI industries - those most likely to be targeted by the Action Plans

[22]One may be concerned that Action Plans mechanically increase coal prices if new pollution control equipment requires higher-quality and thus more expensive grades of coal (which is unobserved) to be operated. We directly test this simultaneity concern by omitting coal prices from our main specifications for both the extensive and intensive margins, and find that the coefficient on Stacked SCAP remains nearly identical.

- report some pollution control stock. Results are similar when we control for a linear time trend in column (2). The coefficient on the interaction term (SCAP X HPI X Large), 0.0946 in column (2), suggests that treatment increased the probability of non-zero abatement investment by about 9.5 percentage points.[23]

In contrast, the Action Plans are associated with a reduction in the probability that small establishments - those least likely to be targeted by the Action Plans - reported any pollution control investment. In terms of coal use, we continue to find no relationship between the Action Plans and the extensive margin of coal use in Columns (3) and (4). There is no evidence that Action Plans moved establishments to give up the use of coal or begin to use coal even when we distinguish across establishment size and HPI status.

One potential explanation for the contrasting findings on investment in pollution abatement is that regulators may have focused their attention even more strongly on large, HPI establishments following the advent of the Action Plans, in order to maximize potential returns by targeting the largest polluters, thus allowing non-targeted establishments to reduce their pollution control efforts. It is interesting to use the data reported in Appendix B to try to estimate the net impact from the opposing effects exhibited in Table 4. Since more than fifty percent of the sample consists of smaller enterprises, while only 12 percent of the sample falls into the category of large HPI enterprises, overall the drop in the number of smaller non-HPI establishments investing in pollution abatement in column (2) is nearly equivalent to the number of large HPI enterprises moving from non-zero investment into positive investment. Yet because the large HPI enterprises accounted for nearly half of all industrial output in India in 2008, while the small non-HPI enterprises accounted for only 5 percent of total output, the additional gains from investment in pollution abatement for the large HPI establishments outweighed the reductions for the small establishments. As we see in Appendix B, the average investment in pollution abatement for establishments that previously had no such investments were 58 times higher than a typical initial investment by a small non-HPI establishments. The results also point to increased abatement investments for large

[23] We also run all specifications including HPI-by-year fixed effects. Doing so reduces the coefficient estimate on SCAP X HPI X Large from 9.5% to roughly 7.1%. This is expected however, as our identification strategy leverages differential targeting between HPI and non-HPI establishments over time. Our preferred specification thus omits these fixed effects.

non-HPI establishments. These results indicate that the establishments that changed their behavior to invest in pollution abatement were large enterprises in dirty sectors and made very large investments.

We now turn to the intensive margin results, measuring the determinants of changes in intensity of coal use or pollution abatement for establishments with non-zero observations. Table 5 reports the impact of the Action Plans and mean district coal prices on changes in within-establishment pollution abatement investment and coal use. The results show that the net impact of Action Plans on the intensive margin of pollution abatement was negligible. Turning to the determinants of coal use, the coefficient on the time trend in Table 5 implies that over time, manufacturing establishments have reduced their consumption of coal. However, the coefficient on the interaction between the time trend and the Action Plans suggests that this trend was nullified for the average establishment in an Action Plan district.

The last two rows of Table 5 report the impact of log mean district coal prices (excluding the establishment's own price) on coal consumption. The results in columns (3) to (5) indicate that a 10 percent increase in coal price is associated with a 5-10 percent reduction in establishment level coal use, and a similar reduction in coal intensity of output. These results suggest that while the Action Plans had some impact on the extensive margin of pollution abatement, coal price changes were the major driver of coal use.

Table 6 decomposes the intensive margin results by establishment size and HPI status. These results suggest that the Action Plans were not associated with an improvement in within-establishment outcomes. In fact, if anything, the Action Plans are associated with disinvestment in pollution control among small, non-HPI establishments. This finding is consistent with our results for the impact of Action Plans on behavior at the extensive margin, where we saw that small, non-HPI establishments were less likely to engage in abatement investments with Action Plans. As we hypothesized earlier, our results suggest that Action Plans may have encouraged further targeting of major emitters, thus increasing the fraction of large, HPI establishments required to install pollution control equipment, but allowing backsliding on the part of small, non-HPI establishments.

For coal use, the results in Table 6 confirm previous findings that the Action Plans appear, if anything, to have offset the secular reduction in coal use. As before, coal prices appear to be the main driver of within-establishment coal use.

Taken together, the extensive and intensive margin results indicate that the only impact of the Action Plans on establishment level investments in abatement and reductions in coal use was to encourage some large enterprises in the HPI sector to shift from zero to positive investments in pollution abatement. While a number of smaller enterprises were likely to divest themselves of pollution control equipment, given the relative sizes of observed investment, we estimate that the net effect of these two offsetting consequences associated with the Action Plans was likely to be positive.

5.1 Productivity, Entry, and Exit

So far, we have considered the effects of the Action Plans and coal prices on directly related outcomes: investment in pollution control equipment and coal use. We saw that higher coal prices are associated with lower coal consumption and coal intensity of output. We also saw that the Action Plans appear to have increased the extensive margin of pollution abatement among large, HPI establishments, with some offsetting disinvestment in pollution abatement among small, non-HPI establishments.

We now consider how these two policies have affected TFP (Table 7). Looking at overall trend changes in TFP over time, the coefficient on the time trend reveals that TFP has been steadily increasing over event time, with TFP growing on average between 0.6 and 1 percentage point per year in terms of gross output.[24] The coefficient on the Action Plans interacted with the time trend is consistently negative and significant, suggesting that establishments affected by Action Plans exhibited lower productivity growth. The magnitude of the interaction term is equal and opposite in sign to trend TFP growth, suggesting that the Action Plans completely offset the overall trend growth rates.

The coefficients on the Action Plans, interacted with the HPI and size dummies, suggest that Action Plans were associated with a significant productivity decline for large, HPI establishments. However, TFP increased in small, non-HPI establishments located in Action Plan

[24]The LP specification is in terms of value added rather than output and thus is not directly comparable to the other estimates.

districts. This result is consistent with our earlier finding that the Action Plans are associated with a disinvestment in pollution control equipment among small, HPI establishments, potentially due to a re-focusing of regulatory attention on larger, HPI establishments.

Table 7 also shows that the coal price is typically (although not always significantly) associated with lower productivity, which is consistent with the revenue productivity definition that we use here. Overall, the results point to some productivity costs of both CAC programs as well as coal price changes. The evidence suggests that the reduction in coal use due to higher coal prices is not associated with sufficient induced innovation to offset the revenue TFP declines.

The effects discussed so far are, by construction, only defined for surviving establishments. However, a key issue in the debate about environmental regulations revolves around the potential effects on entry and exit. Tables 8 and 9 thus return to the extensive margin, and examine whether the Action Plans and coal prices affect probability of establishment exit or entry. As noted above, in these specifications we do not include establishment fixed effects, in order to estimate the relationship using *all* establishments, not just those that entered or exited during our sample period. Thus, we can also include a dummy variable indicating whether an establishment was HPI.

In Table 8, the negative and significant coefficient on the time trend suggests that exit probabilities had been declining over event time. The coefficients on the Action Plans are generally insignificant and close to zero in magnitude for all types of establishments, indicating no relationship between CAC mechanisms and exit probabilities. Although the coefficient on district coal prices is positive, indicating that higher coal prices are associated with higher exit probabilities, the effects are economically insignificant in magnitude and not significant at conventional levels.

Table 9 explores the relationship between entry, environmental regulations, and coal prices. While Action Plans do not appear correlated with exit, they are correlated with a lower probability of entry. In contrast to the results from Table 8, the time trend here suggests a secular increase in entry probabilities over time. However, the interaction between SCAP and the time trend indicates that this increasing trend is being offset in Action Plan districts. Column (8) shows some evidence that the entry deterrence effect is particularly strong in HPI industries, however this not robust to the IV specification in column (9). Designation as an HPI industry alone, however, does not predict entry or exit. There does however, appear to be evidence in support of a statistically significant relationship between higher coal prices and lower entry.

To summarize the impact of Action Plans on establishment outcomes so far, we see that they have affected behavior at the extensive margin but not at the intensive margin. In particular, Action Plan passage is associated with the initiation of investments in pollution abatement for large HPI enterprises, but the opposite for smaller, in particular non-HPI sectors. Consistent with the differential effects of Action Plans combined with HPI designations on abatement investment, we also find reduced TFP in large HPI establishments with Action Plans but higher TFP in smaller establishments bypassed by the regulation. In addition, Action Plan passage did not significantly affect exit but did discourage entry, particularly among HPI establishments.

5.2 Air Quality

So far, we have shown that both the Action Plans and coal prices affected establishment outcomes, albeit in different ways. In this section we ask whether these policies had any impact on air quality.

Supreme Court Action Plans could have influenced emissions through a variety of measures mandated by the plans. The different plans had components targeted at vehicles, which could lead to a direct relationship between Action Plan passage and different measures of air pollution if measures were implemented effectively. However, other components of these plans focused on HPI sectors and as we saw, encouraged investment in pollution abatement among large establishments. For these plan components, we would expect Action Plan passage to affect emissions through changes in pollution abatement, if such abatement effectively reduced emissions. [25]

Table 10 shows the results from a district-level regression in which the outcome variables are SPM, SO2 and NO2 concentrations. Panel (a) shows results in which districts are equally

[25]Since Action Plan measures directly targeted emissions, we cannot use Action Plan passage as an instrument for district level investments in pollution abatement, which would be an ideal instrument otherwise.

weighted; panel (b) shows results in which districts are weighted based on the initial number of establishments. It is important to note that air quality monitoring data are only available from a subset of cities and years (see Figure 1). Thus, the results may not be nationally representative, but based on Figure 1, monitors cover most Action Plan areas.

Consistent with Greenstone and Hanna (2014), we find that the Action Plans had little impact on overall SPM or SO2 concentrations but did reduce NO2.[26] For NO2, our evidence suggests that while NO2 concentrations demonstrated a secular rise over time; the Action Plans appear to have reversed this trend.

In contrast, coal prices appear to be more effective in reducing SO2 pollution.[27] Since SO2 levels are primarily associated with the burning of fossil fuels, the significant and negative impact of rising coal prices on SO2 emissions is plausible. The negative coefficient, which varies between -0.116 and -0.162, indicates that a 10 percent rise in coal prices at the district level was associated with a reduction in SO2 emissions of between 1 and 2%.

6 Conclusions

While India's rapid growth and spectacular rate of poverty reduction has brought many benefits, it has also contributed to a rapid increase in air pollution. India now holds the dubious distinction of being home to 13 of the 20 cities in the world with the worst air quality.

India's Ministry of the Environment and Forests, Central Pollution Control Board, Supreme Court, State Pollution Control Boards, and myriad other bodies have enacted many reforms to address this highly visible problem. Historically, India has relied primarily on command-and-control mechanisms to encourage its industrial establishments to tackle environmental problems. In 1991 the MoEF identified 17 highly polluting industries which were further monitored and regulated at both the central government and state government levels. India's Supreme Court also required that a number of cities mandate catalytic converters for

[26] In Appendix A, we also replicate the exact analogs to the pollution regressions in Greenstone and Hanna (2014) and find similar results.

[27] In air pollutant specifications we use the log mean district price of coal. While the Hausman IV discussed is well suited for estimating demand elasticities, without industry and firm-level variation the IV becomes weak.

new cars and enact Action Plans, which targeted a number of pollution sources, including establishments in highly polluting industries.

Beyond the usual arguments that economic incentives are more likely than command-and-control regulations to promote efficiency and innovation, in a complex and large country such as India, it is also possible that economic incentives may also help to overcome institutional barriers to implementation. In recognition of this fact, the Indian government in 2010 introduced a tax of Rs. 50 per metric ton of coal. The revenues from this Clean Energy Cess, as it is known, are intended to be used for environmental purposes. In 2014, the tax was doubled. The Indian government further demonstrated its commitment to consider price mechanisms in 2013 by spearheading a large-scale emissions trading scheme pilot for particulate matter (CPCB, 2013).

In this paper we compare the effects of a command-and-control approach with price incentives on investment in pollution abatement and coal use across establishments. Command-and-control policies refer to the extensive use of Supreme Court Action Plans to address India's environmental challenges. Price incentives are captured in our analysis through district-level variations in coal prices. To our knowledge, this is the first study to use the comprehensive establishment-level Annual Survey of Industries (ASI) to assess the effectiveness of India's environmental regulations. We also measure the impact of these different mechanisms on other establishment-level outcomes, namely productivity growth, entry and exit. Examining these non-environmental outcomes is important because we are interested in whether it is possible to formulate an environmental policy that minimizes foregone growth, or as some authors have argued, even enhances such outcomes.

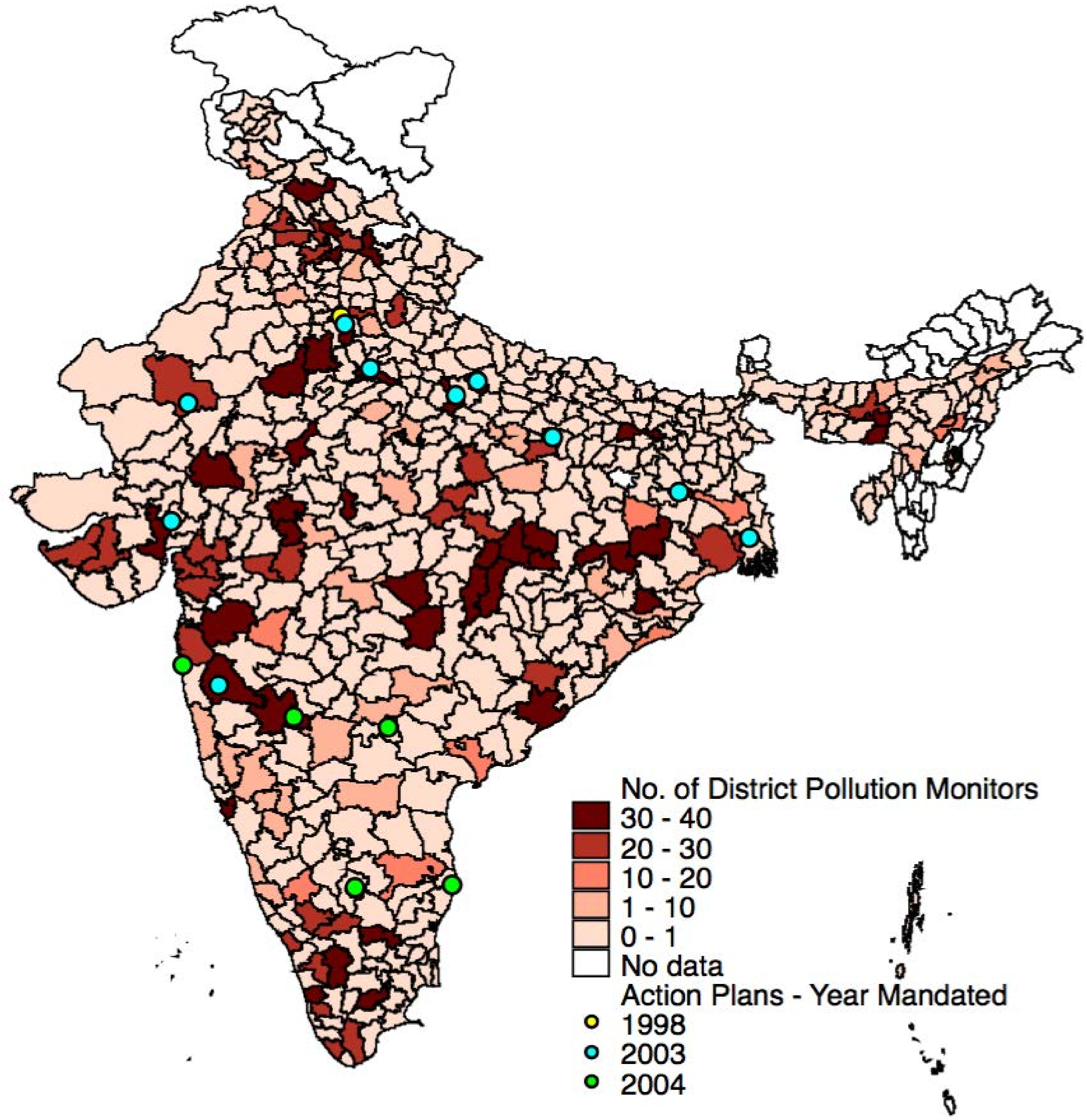
The main impact of the Action Plans appears to have been an increase in the external margin of pollution abatement among large establishments in highly polluting industries, which were already substantially more likely than other establishments to invest in pollution abatement. At the same time, the Action Plans are associated with a decrease in both the extensive and intensive margins of pollution abatement among small, non-HPI establishments, suggesting that regulators may have increased their focus on establishments where they would get the most "bang for the buck."

Our results on coal prices provide broad support for the Indian government's recent efforts to address pollution problems through fuel taxes. Higher coal prices significantly reduced coal consumption at the establishment level, with price elasticities consistently estimated between -0.58 and -1.02, in line with estimates reported in industrial country studies. Higher coal prices are also associated with a (small) increase in exit and a larger deterrence to entry.

The results suggest that Supreme Court Action Plans were also accompanied by partial reversals in productivity growth, and with lower entry, particularly among highly-polluting industries. The only evidence of a potential "double dividend" comes from small, non-HPI establishments, which showed an increase in productivity; however, this may be driven by disinvestment in pollution abatement equipment following the Action Plans, or by a related decline in employment from other policy changes, in particular the dismantling of the Small Scale Reservation policies (Martin et al., 2014).

In keeping with previous work, we find that the Action Plans may have reversed the previously increasing trend in NO2 concentrations, but had little or no impact on other air quality measures. However, higher coal prices are associated with lower SO2 concentrations. Taken together, our results suggest that the Action Plans focused attention even more strongly on the large, highly polluting establishments that were already most regulated. From this perspective, our results suggest that price-based policies could be a more powerful tool for broadening the scope of regulation to include smaller establishments in industries that have not been traditionally targeted, without imposing an additional burden on regulators.

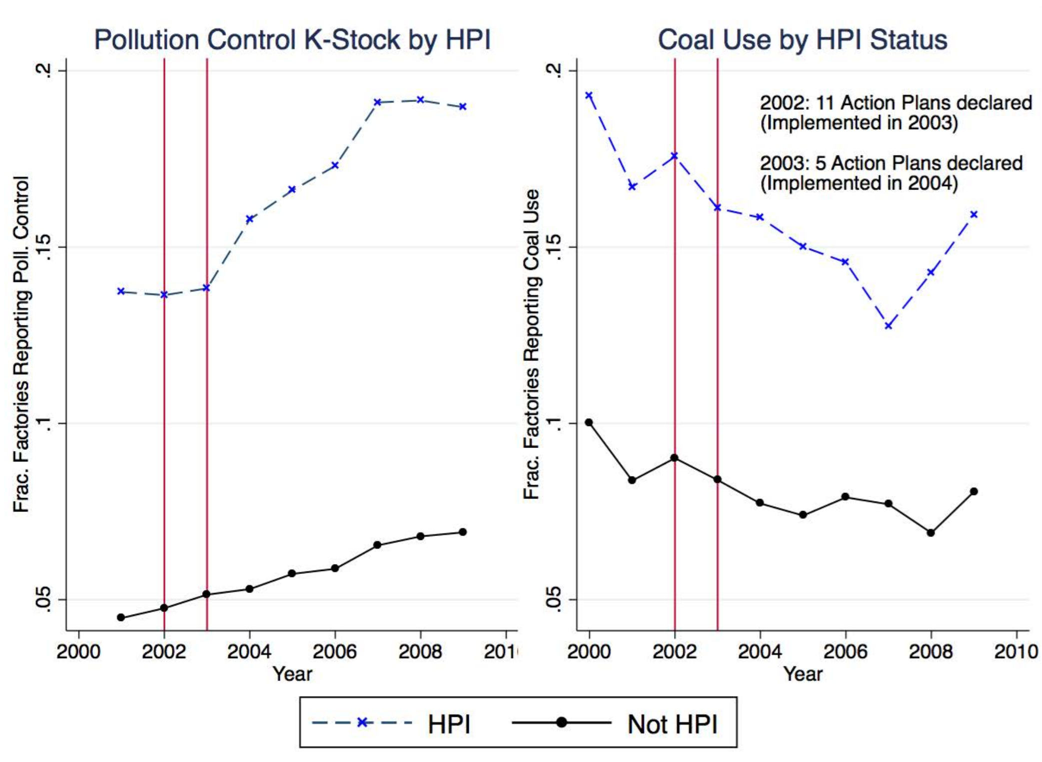
Figure 1: Locations of Action Plans and Air Pollution Monitors



Note: Action Plans in large cities in the South of India such as Bangalore, Hyderabad, and Chennai in fact overlap with a high density of monitors, which is not easily seen on the map given the small geographic size of these cities' surrounding districts.

Figure 2: Fraction of Establishments Reporting Positive Use

Panel A: By HPI



Panel B: By SCAP

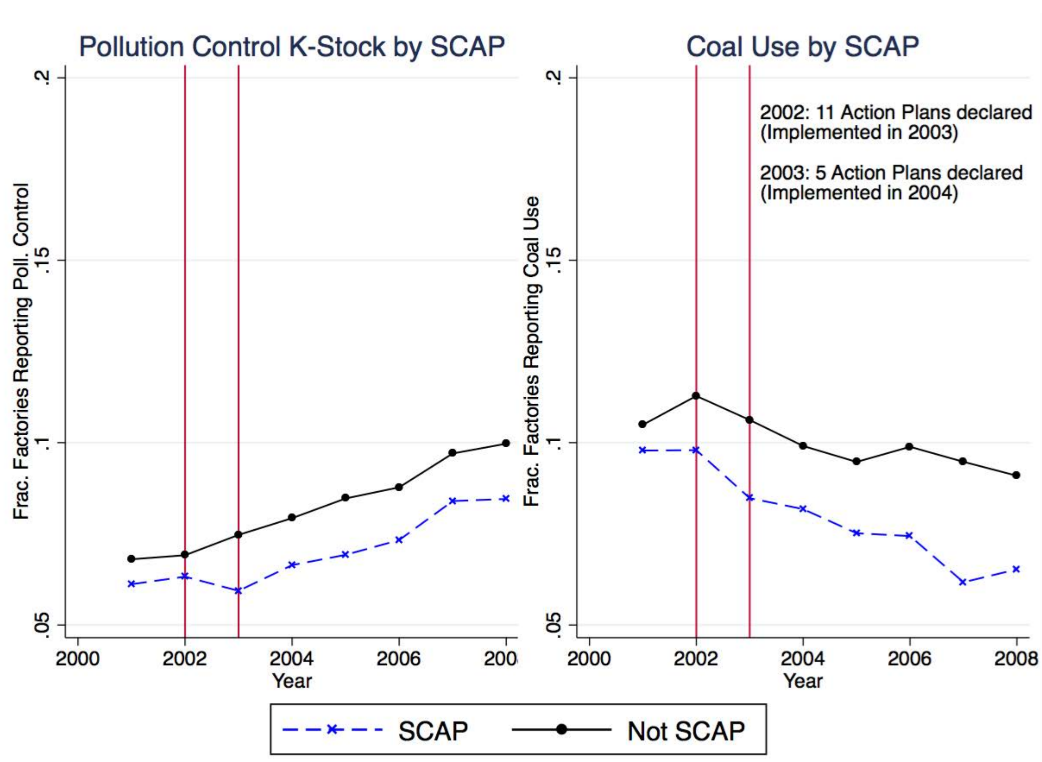


Table 1: Supreme Court Action Plan (SCAP) Implementation

1998	**2003**	**2004**
Delhi	Agra	Bangalore
	Ahmedabad	Chennai
	Calcutta	Hyderabad
	Dhanbad	Mumbai
	Faridabad	Solapur
	Jodhpur	
	Kanpur	
	Lucknow	
	Patna	
	Pune	
	Varanasi	

Table 2: Summary Statistics by SCAP, HPI, and Large Sub-Groups

	SCAP	NotSCAP	HPI	NotHPI	Large	NotLarge	Overall
Pollution Control Stock (INR 1000s)	258	969	2,970	145	2,405	70	845
	(3,935)	(25,048)	(45,405)	(3,404)	(39,516)	(1,518)	(22,827)
Pollution Control Stock / Capital	0.003	0.004	0.007	0.002	0.005	0.003	0.003
	(0.026)	(0.027)	(0.037)	(0.022)	(0.028)	(0.026)	(0.026)
PollUser (Ever Use Pollution Control)	0.092	0.115	0.221	0.075	0.218	0.057	0.111
	(0.289)	(0.319)	(0.415)	(0.263)	(0.413)	(0.233)	(0.314)
Coal Tons	246	2,174	6,737	224	5,324	94	1,847
	(3,959)	(55,850)	(101,613)	(4,060)	(87,858)	(2,590)	(50,921)
Coal Tons / Output	0.000	0.000	0.000	0.000	0.000	0.000	0.000
	(0.000)	(0.017)	(0.022)	(0.011)	(0.001)	(0.021)	(0.016)
CoalUser (Ever Use Coal)	0.088	0.123	0.162	0.102	0.152	0.100	0.117
	(0.284)	(0.329)	(0.369)	(0.303)	(0.359)	(0.299)	(0.322)
Employment	217	181	218	177	470	44	187
	(851)	(746)	(830)	(742)	(1,261)	(107)	(765)
Mean District Coal Price (excl. own)	2,712	2,593	2,558	2,632	2,615	2,611	2,613
	(797)	(862)	(875)	(844)	(824)	(867)	(853)
TFP (OLS)	-0.090	-0.040	-0.086	-0.036	-0.199	0.028	-0.049
	(0.428)	(0.433)	(0.421)	(0.436)	(0.480)	(0.384)	(0.433)
TFP (Olley-Pakes)	2.246	2.216	2.173	2.237	2.260	2.201	2.221
	(0.427)	(0.457)	(0.404)	(0.466)	(0.508)	(0.419)	(0.452)
TFP (Levinsohn-Petrin)	9.991	10.221	9.276	10.491	9.915	10.315	10.181
	(9.476)	(12.567)	(8.020)	(13.179)	(12.447)	(11.908)	(12.087)
TFP (ACR Revenue Share)	-0.021	-0.055	-0.036	-0.053	-0.053	-0.047	-0.049
	(0.424)	(0.399)	(0.399)	(0.405)	(0.426)	(0.391)	(0.404)
TFP (ACR Cost Share)	-0.015	-0.035	-0.007	-0.040	-0.019	-0.038	-0.031
	(0.412)	(0.396)	(0.419)	(0.391)	(0.445)	(0.371)	(0.399)
Entry	0.112	0.137	0.143	0.130	0.103	0.147	0.133
	(0.315)	(0.344)	(0.350)	(0.336)	(0.304)	(0.354)	(0.340)
Exit	0.073	0.055	0.052	0.059	0.044	0.064	0.058
	(0.260)	(0.227)	(0.222)	(0.236)	(0.205)	(0.246)	(0.233)
N	51966	254084	76216	229834	102235	202179	306050

Note: 1 USD = Approximately 50 INR over sample period. Nominal variables are rounded to whole numbers.

Table 3: Effect of Action Plans on Extensive Margin of Pollution Control and Coal Use

VARIABLES	(1) P(Poll. Control Use)	(2) P(Poll. Control Use)	(3) P(Coal Use)	(4) P(Coal Use)
Stacked SCAP	-0.00369	0.00272	-0.00705	-0.00245
	(0.00357)	(0.00225)	(0.00672)	(0.00388)
Stacked Time Trend		-0.00390**		-0.00524*
		(0.00161)		(0.00303)
SCAP X Trend		0.00252		0.00522
		(0.00167)		(0.00319)
Log mean district coal price (excluding own)	0.00133	0.00156	-0.00507	-0.00456
	(0.00271)	(0.00275)	(0.00495)	(0.00500)
Observations	282,552	282,552	305,190	305,190
R^2	0.029	0.029	0.003	0.004
Number of firmid	88,282	88,282	89,911	89,911
Establishment FE	Yes	Yes	Yes	Yes
Year FE	Yes	Yes	Yes	Yes

Table 4: Effect of Action Plans on Extensive Margin of Pollution Control and Coal Use, by HPI and Size

VARIABLES	(1) P(Poll. Control Use)	(2) P(Poll. Control Use)	(3) P(Coal Use)	(4) P(Coal Use)
SCAP X HPI X Large	0.0877***	0.0946***	-0.0208	-0.0164
	(0.0246)	(0.0231)	(0.0185)	(0.0161)
SCAP X HPI X Not large	-0.00675	-0.000150	-0.0165	-0.0122
	(0.00564)	(0.00562)	(0.0183)	(0.0137)
SCAP X Not HPI X Large	0.0132*	0.0202***	6.60e-05	0.00449
	(0.00681)	(0.00683)	(0.00752)	(0.00548)
SCAP X Not HPI X Not large	-0.0149***	-0.00821***	-0.00496	-0.000460
	(0.00314)	(0.00300)	(0.00470)	(0.00554)
Stacked Time Trend		-0.00377**		-0.00518*
		(0.00160)		(0.00308)
SCAP X Trend		0.00226		0.00519
		(0.00164)		(0.00322)
Log mean district coal price (excluding own)	0.00121	0.00143	-0.00510	-0.00459
	(0.00269)	(0.00273)	(0.00493)	(0.00498)
Observations	281,013	281,013	303,563	303,563
R^2	0.031	0.031	0.004	0.004
Number of firmid	87,775	87,775	89,392	89,392
Establishment FE	Yes	Yes	Yes	Yes
Year FE	Yes	Yes	Yes	Yes

Standard errors clustered at the district level. *** p<0.01, ** p<0.05, * p<0.1

Table 5: Effect of Action Plans on Intensive Margin of Pollution Control and Coal Use

VARIABLES	(1) Log Pollution Control	(2) Log Pollution Control / Capital	(3) Log Coal Tons	(4) Log Coal Tons	(5) Log Coal Tons / Output	(6) Log Coal Tons / Output
Stacked SCAP	0.0118	-0.0438	0.0669	0.0553	0.0267	0.0155
	(0.0658)	(0.0877)	(0.0815)	(0.0875)	(0.0768)	(0.0845)
Stacked Time Trend	-0.0456	-0.0240	-0.103**	-0.0914*	-0.0411	-0.0264
	(0.0533)	(0.0556)	(0.0489)	(0.0505)	(0.0522)	(0.0469)
SCAP X Trend	0.0238	0.00693	0.0914**	0.0848**	0.0275	0.0168
	(0.0595)	(0.0574)	(0.0405)	(0.0344)	(0.0480)	(0.0409)
Log mean district coal price (excluding own)	-0.0709	-0.100*	-0.579***		-0.552***	
	(0.0504)	(0.0552)	(0.104)		(0.0922)	
Log coal price (own) - Hausman IV 2nd Stage				-0.991***		-0.933***
				(0.233)		(0.192)
Observations	31,366	31,269	35,891	31,303	35,874	31,286
R^2	0.028	0.050	0.019	0.148	0.015	0.161
Number of firmid	8,032	8,033	12,499	8,379	12,496	8,376
Establishment FE	Yes	Yes	Yes	Yes	Yes	Yes
Year FE	Yes	Yes	Yes	Yes	Yes	Yes
First Stage F-Stat				79.64		79.53

Table 6: Effect of Action Plans on Intensive Margin of Pollution Control and Coal Use, by HPI and Size

VARIABLES	(1) Log Pollution Control	(2) Log Pollution Control / Capital	(3) Log Coal Tons	(4) Log Coal Tons	(5) Log Coal Tons / Output	(6) Log Coal Tons / Output
SCAP X HPI X Large	-0.0613	-0.172**	0.0969	0.0730	0.0890	0.0620
	(0.0823)	(0.0791)	(0.128)	(0.173)	(0.126)	(0.134)
SCAP X HPI X Not large	0.175	0.206	0.0847	0.112	0.0138	0.0514
	(0.232)	(0.220)	(0.168)	(0.192)	(0.135)	(0.147)
SCAP X Not HPI X Large	0.114	0.103	-0.150	-0.257	-0.171	-0.271**
	(0.0831)	(0.104)	(0.252)	(0.194)	(0.180)	(0.129)
SCAP X Not HPI X Not large	-0.170***	-0.303***	0.106	0.0955	0.0786	0.0598
	(0.0451)	(0.117)	(0.111)	(0.102)	(0.109)	(0.106)
Stacked Time Trend	-0.0507	-0.0309	-0.101**	-0.0890*	-0.0395	-0.0240
	(0.0536)	(0.0598)	(0.0481)	(0.0485)	(0.0520)	(0.0459)
SCAP X Trend	0.0261	0.0102	0.0916**	0.0850**	0.0273	0.0165
	(0.0609)	(0.0629)	(0.0407)	(0.0345)	(0.0482)	(0.0414)
Log mean district coal price (excluding own)	-0.0727	-0.102*	-0.580***		-0.551***	
	(0.0513)	(0.0550)	(0.104)		(0.0925)	
Log coal price (own) - Hausman IV 2nd Stage				-1.002***		-0.943***
				(0.234)		(0.191)
Observations	31,201	31,106	35,716	31,160	35,699	31,143
R^2	0.029	0.052	0.019	0.148	0.015	0.161
Number of firmid	7,980	7,981	12,443	8,352	12,440	8,349
Establishment FE	Yes	Yes	Yes	Yes	Yes	Yes
Year FE	Yes	Yes	Yes	Yes	Yes	Yes
First Stage F-Stat				78.85		78.76

Standard errors clustered at the district level. *** p<0.01, ** p<0.05, * p<0.1

Table 7: Effect of Action Plans on TFP, by HPI and Size

	(1)	(2)	(3)	(4)	(5)
		ACR	ACR		
VARIABLES	OLS	(RevShare)	(CostShare)	OP	LP
SCAP X HPI X Large	-0.0324***	-0.0303***	-0.0282***	-0.0189*	-0.141
	(0.00834)	(0.0108)	(0.0105)	(0.00982)	(0.107)
SCAP X HPI X Not large	-0.0128	-0.00778	-0.00697	-0.0104	-0.182
	(0.0102)	(0.00835)	(0.00860)	(0.00958)	(0.133)
SCAP X Not HPI X Large	0.00710	6.31e-05	0.00111	0.0131	0.232
	(0.0122)	(0.0109)	(0.00956)	(0.0156)	(0.227)
SCAP X Not HPI X Not large	0.0187***	0.0134**	0.0171***	0.0171***	0.188*
	(0.00618)	(0.00672)	(0.00540)	(0.00519)	(0.100)
Stacked Time Trend	0.00757**	0.00644	0.00920**	0.0102**	0.211***
	(0.00294)	(0.00417)	(0.00373)	(0.00400)	(0.0611)
SCAP X Trend	-0.00835**	-0.00644	-0.00983**	-0.0109**	-0.212***
	(0.00371)	(0.00490)	(0.00422)	(0.00449)	(0.0572)
Log mean district coal price (excluding own)	-0.0182**	-0.00226	-0.00753	-0.0166**	-0.182
	(0.00734)	(0.00605)	(0.00624)	(0.00715)	(0.112)
Observations	291,472	296,196	296,196	296,089	286,271
R^2	0.007	0.011	0.015	0.002	0.005
Number of firmid	86,547	88,201	88,201	88,140	86,581
Establishment FE	Yes	Yes	Yes	Yes	Yes
Year FE	Yes	Yes	Yes	Yes	Yes

Standard errors clustered at the district level. *** p<0.01, ** p<0.05, * p<0.1

Table 8: Effect of Action Plans on Exit

VARIABLES	(1) Pr(Exit)	(2) Pr(Exit)	(3) Pr(Exit)	(4) Pr(Exit)	(5) Pr(Exit)	(6) Pr(Exit)	(7) Pr(Exit)	(8) Pr(Exit)	(9) Pr(Exit)
Stacked SCAP	0.00540	0.00703	0.0121	0.0103	0.00977	0.0103	0.00956		
	(0.00747)	(0.00727)	(0.0136)	(0.0129)	(0.0157)	(0.0129)	(0.0159)		
Stacked Time Trend			-0.00773**	-0.00835**	-0.00748	-0.00830**	-0.00722	-0.00835**	-0.00728
			(0.00344)	(0.00379)	(0.0105)	(0.00380)	(0.0106)	(0.00379)	(0.0105)
SCAP X Trend			0.00546	0.00623	0.00620	0.00620	0.00585	0.00629	0.00619
			(0.00530)	(0.00556)	(0.0140)	(0.00558)	(0.0141)	(0.00558)	(0.0138)
Stacked SCAP X HPI								-0.00192	-0.00194
								(0.0121)	(0.0148)
Stacked SCAP X Not HPI								0.0138	0.0177
								(0.0131)	(0.0175)
HPI						-0.00412*	0.00444	-0.00230	0.00626
						(0.00228)	(0.00456)	(0.00249)	(0.00470)
Log mean district coal price (excluding own)	0.0178*			0.0181*		0.0178*		0.0177*	
	(0.00938)			(0.00938)		(0.00924)		(0.00927)	
Log coal price (own) - Hausman IV 2nd Stage		0.00427			0.00422		0.00311		0.00400
		(0.00902)			(0.00899)		(0.00884)		(0.00893)
Constant	-0.0772	0.0278	0.0544***	-0.0878	0.0190	-0.0845	0.0261	-0.0845	0.0184
	(0.0728)	(0.0686)	(0.00670)	(0.0728)	(0.0695)	(0.0714)	(0.0686)	(0.0717)	(0.0694)
Observations	305,190	35,188	306,050	305,190	35,188	305,190	35,188	305,190	35,188
R^2	0.016	0.014	0.016	0.016	0.014	0.016	0.014	0.016	0.014
Establishment FE	No	No	No	No	No	No	No	No	No
Year FE	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes
First Stage F-Stat		378.6			374.8		394.9		410.7

Standard errors clustered at the district level. *** p<0.01, ** p<0.05, * p<0.1

Table 9: Effect of Action Plans on Entry

	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)	(9)
VARIABLES	Pr(Entry)	Pr(Entry)	Pr(Entry)	Pr(Entry)	Pr(Entry)	Pr(Entry)	Pr(Entry)	Pr(Entry)	Pr(Entry)
Stacked SCAP	-0.0283***	-0.0368***	-0.0273**	-0.0246**	-0.0446***	-0.0246**	-0.0443***		
	(0.00825)	(0.00647)	(0.0110)	(0.0114)	(0.00685)	(0.0114)	(0.00682)		
Stacked Time Trend			0.0183***	0.0190***	0.00721	0.0189***	0.00692	0.0189***	0.00691
			(0.00583)	(0.00550)	(0.0121)	(0.00553)	(0.0122)	(0.00553)	(0.0122)
SCAP X Trend			-0.0196***	-0.0206***	-0.00358	-0.0205***	-0.00319	-0.0204***	-0.00317
			(0.00497)	(0.00470)	(0.0128)	(0.00472)	(0.0128)	(0.00469)	(0.0128)
Stacked SCAP X HPI								-0.0451***	-0.0451***
								(0.0102)	(0.00728)
Stacked SCAP X Not HPI								-0.0188	-0.0438***
								(0.0118)	(0.00916)
HPI						0.00502	-0.00496	0.00807*	-0.00484
						(0.00411)	(0.00592)	(0.00452)	(0.00656)
Log mean district coal price (excluding own)	-0.0218***			-0.0224***		-0.0221***		-0.0222***	
	(0.00796)			(0.00784)		(0.00780)		(0.00779)	
Log coal price (own) - Hausman IV 2nd Stage		-0.0412***			-0.0411***		-0.0399***		-0.0398***
		(0.00967)			(0.00974)		(0.00966)		(0.00985)
Constant	0.276***	0.387***	0.130***	0.307***	0.394***	0.303***	0.386***	0.302***	0.385***
	(0.0635)	(0.0751)	(0.0110)	(0.0628)	(0.0740)	(0.0624)	(0.0732)	(0.0623)	(0.0749)
Observations	305,190	35,188	306,050	305,190	35,188	305,190	35,188	305,190	35,188
R^2	0.005	0.005	0.005	0.006	0.005	0.006	0.005	0.006	0.005
Establishment FE	No	No	No	No	No	No	No	No	No
Year FE	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes
First Stage F-Stat		378.6			374.8		394.9		410.7

Standard errors clustered at the district level. *** p<0.01, ** p<0.05, * p<0.1

Table 10: Effect of Action Plans on District-Level Pollution

Panel A: Each district equally weighted

VARIABLES	(1) log(SPM)	(2) log(SPM)	(3) log(SO2)	(4) log(SO2)	(5) log(NO2)	(6) log(NO2)
Stacked SCAP	-0.185*	-0.118	-0.0537	0.0151	0.178*	0.00218
	(0.0953)	(0.141)	(0.109)	(0.0937)	(0.104)	(0.0971)
Stacked Time Trend		0.00783		-0.0729		0.188***
		(0.0831)		(0.0630)		(0.0688)
SCAP X Trend		-0.0307		0.0723		-0.187**
		(0.0874)		(0.0743)		(0.0829)
Log mean district price coal	0.0106	0.00647	-0.118**	-0.116*	-0.0212	-0.0267
	(0.0497)	(0.0499)	(0.0582)	(0.0587)	(0.0389)	(0.0377)
Coal Use, Power Plants	0.00705	0.00553	-0.00257	-0.00313	0.00452	0.00600
	(0.0107)	(0.0108)	(0.0208)	(0.0213)	(0.0145)	(0.0139)
Observations	666	666	642	642	680	680
R^2	0.381	0.382	0.107	0.109	0.024	0.040
Number of districtid	109	109	103	103	108	108
District FE	Yes	Yes	Yes	Yes	Yes	Yes
Year FE	Yes	Yes	Yes	Yes	Yes	Yes

Standard errors clustered at the district level. *** p<0.01, ** p<0.05, * p<0.1

Panel B: Weighted by initial number of establishments in each district

VARIABLES	(1) log(SPM)	(2) log(SPM)	(3) log(SO2)	(4) log(SO2)	(5) log(NO2)	(6) log(NO2)
Stacked SCAP	-0.153	-0.0596	-0.0575	-0.0935	0.0573	-0.0736
	(0.125)	(0.101)	(0.119)	(0.109)	(0.117)	(0.110)
Stacked Time Trend		-0.0145		-0.0734		0.148*
		(0.0721)		(0.0703)		(0.0805)
SCAP X Trend		-0.0126		0.107		-0.147
		(0.0881)		(0.0956)		(0.107)
Log mean district price coal	0.0382	0.0322	-0.162**	-0.139*	-0.0552	-0.0785
	(0.0660)	(0.0655)	(0.0716)	(0.0752)	(0.0729)	(0.0648)
Coal Use, Power Plants	0.0201	0.0168	0.0266	0.0299	0.00762	0.00945
	(0.0284)	(0.0296)	(0.0270)	(0.0264)	(0.0205)	(0.0203)
Observations	663	663	639	639	677	677
R^2	0.399	0.401	0.099	0.108	0.013	0.033
Number of districtid	107	107	101	101	106	106
District FE	Yes	Yes	Yes	Yes	Yes	Yes
Year FE	Yes	Yes	Yes	Yes	Yes	Yes

Standard errors clustered at the district level. *** p<0.01, ** p<0.05, * p<0.1

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7 Appendix A

Table 11: Effect of Action Plans on District-Level Pollution

Panel A: Each district equally weighted

VARIABLES	(1) log(SPM)	(2) log(SPM)	(3) log(SO2)	(4) log(SO2)	(5) log(NO2)	(6) log(NO2)
Stacked SCAP	-0.197**	-0.129	-0.0761	-0.00461	0.168	0.00430
	(0.0949)	(0.140)	(0.108)	(0.0977)	(0.104)	(0.0959)
Stacked Time Trend		0.00747		-0.0825		0.173***
		(0.0814)		(0.0582)		(0.0619)
SCAP X Trend		-0.0303		0.0847		-0.173**
		(0.0860)		(0.0699)		(0.0784)
Observations	701	701	666	666	712	712
R^2	0.383	0.384	0.097	0.099	0.024	0.038
Number of districtid	110	110	104	104	109	109
District FE	Yes	Yes	Yes	Yes	Yes	Yes
Year FE	Yes	Yes	Yes	Yes	Yes	Yes

Standard errors clustered at the district level. *** p<0.01, ** p<0.05, * p<0.1

Panel B: Weighted by initial number of establishments in each district

VARIABLES	(1) log(SPM)	(2) log(SPM)	(3) log(SO2)	(4) log(SO2)	(5) log(NO2)	(6) log(NO2)
Stacked SCAP	-0.156	-0.0599	-0.103	-0.108	0.0505	-0.0709
	(0.127)	(0.105)	(0.117)	(0.120)	(0.111)	(0.103)
Stacked Time Trend		-0.00539		-0.102		0.127
		(0.0730)		(0.0633)		(0.0767)
SCAP X Trend		-0.0249		0.135		-0.124
		(0.0876)		(0.0900)		(0.106)
Observations	694	694	659	659	705	705
R^2	0.400	0.403	0.077	0.090	0.009	0.024
Number of districtid	108	108	102	102	107	107
District FE	Yes	Yes	Yes	Yes	Yes	Yes
Year FE	Yes	Yes	Yes	Yes	Yes	Yes

Standard errors clustered at the district level. *** p<0.01, ** p<0.05, * p<0.1

7.1 Appendix B - Pollution Investment by HPI and Size

Table 12: Shares of Factories, Output and Pollution Control Stock by HPI and Size

	HPI, Large,	HPI, Small	Non-HPI, Large	Non-HPI, Small
Share of factories, 2001	12%	12%	29%	48%
Share of factories, 2008	12%	11%	31%	46%
Share of output, 2001	44%	2%	48%	6%
Share of output, 2008	49%	1%	45%	4%
Share of pollution control stock, 2001	87%	1.1%	11.6%	0.4%
Share of pollution control stock, 2008	84%	0.3%	15.4%	0.4%

Table 13: Average Change in Pollution Control Stock

	Initial Investment	Subsequent Change in Investment
Overall	3,172,747	11,968
Large HPI	8,768,606	258,316
Small HPI	107,399	-6,743
Large Non-HPI	1,832,021	-1,690
Small Non-HPI	151,090	-295