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# Crackdowns in Hierarchies:
# Evidence from China's Environmental Inspections

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**Abstract**

We study how state-led crackdowns under conditions of urgency affect firm behavior. By linking the timing of centralized dispatch of environmental inspectors to cities in response to China's air quality crisis with high-frequency observations of coal power plant pollution, we show that during inspections concentrations of sulfur dioxide ($SO_2$), a major air pollutant, fall on average by 25-27%, but return to prior levels when crackdowns end. A plant's accountability to central versus local regulators affects how long post-inspection reductions last. Allowing citizens to file complaints against polluting plants during crackdowns does not increase long-run effectiveness: high pollution at baseline does not predict complaints, nor do complaints prolong pollution reduction. Our findings suggest that crackdowns may facilitate information transmission among the state hierarchy, firms, and citizenry without achieving permanent performance improvement.

**Keywords:** hierarchy, enforcement, industrial firms

**JEL:** L25, P27, Q53

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# 1 Introduction

Severely polluted air is a byproduct of rapid industrial growth, damaging human health and causing premature death (Chen et al., 2012; Ebenstein et al., 2017; Greenstone and Hanna, 2014). Inadequate enforcement of environmental regulations contributes to these challenges (Duflo et al., 2018; McAllister et al., 2010; Shimshack, 2014), but the causes and extent of implementation failures are poorly understood. We study enforcement in China, an industrializing country that has experienced repeated episodes of severely degraded air. Several weeks of hazardous air quality in Beijing in 2013 known as the "Airpocalypse" raised awareness of China's pollution domestically and overseas (Beech, 2013). In late 2015 the central government announced rotating inspections (*huanbao ducha* in Chinese) to strengthen enforcement by city environmental protection bureaus against polluting firms. These inspections constitute an example of an informal institution that temporarily raises central scrutiny of the periphery. In contrast to a substantial focus in the literature on the effectiveness of formal policy levers (Greenstone and Hanna, 2014; Blackman et al., 2018; Tanaka, 2015), no study has examined the ability of crackdowns, an *ad hoc* approach to strengthening enforcement, to improve the effectiveness of governance in hierarchies.

Our primary contribution is to quantify how a centrally-led crackdown, in the form of rotating environmental inspections, affected pollution over time at coal power plants. We quantify effects using high-frequency, plant-level data on the concentrations of a major short-lived industrial air pollutant, sulfur dioxide ($SO_2$). We find that while crackdowns are in progress, pollution falls by 25-27%, a substantial decline.[1] We find that pollution reverts to prior levels within approximate two months after inspectors leave. Reversion occurs most rapidly among firms accountable to the central government, which originated the crackdowns, while cleanup persists longer among firms accountable to the local government. The timing of inspections' announcement, which is exogenous at the city level, is used to identify effects on $SO_2$ pollution. To improve comparability of treatment and control groups across inspection rounds, we employ entropy balancing (Hainmueller, 2012).

By observing how pollution responds during crackdowns, we can probe the origins of China's regulatory enforcement gap. In order to take action to reduce pollution, firm managers must (1) understand that pollution is undesirable, (2) know how to reduce it, and (3) have sufficient incentives to undertake cleanup actions. Our finding that firms clean up substantially during inspections but revert thereafter to prior polluting behavior is most consistent with (3) as the bottleneck. During inspections, firms employ short-term measures that reduce both $SO_2$ emissions and electricity production. After inspections end, plant activity rises above baseline, while $SO_2$ emissions gradually increase to prior levels. Our results are consistent with the absence of continuous transmission of cleanup pressure from the national government, which largely initiates environmental regulation, to city level governments, which are responsible for implementation (Wu et al., 2014).

[1] Changes in $SO_2$ pollution are expressed in log points throughout.

Beyond quantifying the effects of inspections, our findings shed light on strategies used to manage hierarchies when achieving multiple objectives is costly. The short-lived improvements observed during inspections are inconsistent with a mechanism in which central authorities continuously push for environmental improvement against the interests of a self-serving periphery. In settings as diverse as anticorruption campaigns (Qu et al., 2018) to mine safety (Fisman and Wang, 2017) to environmental investments (Eaton and Kostka, 2014; Wu et al., 2014), the central government is often viewed as playing the role of curbing local excesses, enhancing public goods provision, and achieving regional equity. Our findings challenge this view. The short-lived nature of crackdowns and the more rapid reversion of centrally-connected state-owned enterprises suggests that the central authorities may be unable or unwilling to sustain cleanup pressure.

We then consider whether allowing citizens to report on polluters during inspections prolongs cleanup. We study one component of the crackdowns: allowing citizens to complain about pollution via hotlines, mailboxes, and social media while an inspection is in progress. The local environmental protection bureau was required to investigate and formally respond to all complaints against plants located in a city. We probe the effectiveness of citizens' reporting, by asking: (1) are citizens more likely to complain about plants that were poor environmental performers at baseline? (2) do firms receiving complaints clean up more during inspections? and (3) do reductions persist longer at firms receiving complaints, compared to those that do not? We find that citizens do not tend to complain about dirtier plants on average, and although plants receiving complaints reduce pollution more during crackdowns, they also return more rapidly to baseline levels of pollution after crackdowns end.

Our study contributes new insights at the intersection of three literatures. First, we shed light on how crackdowns work in complex state-business hierarchies to a growing literature on the economics of crackdowns (Di Tella and Schargrodsky, 2003; Dell, 2015; Johannesen and Zucman, 2012; Eeckhout et al., 2010). Our estimates provide the first empirical evidence of how crackdowns, a common government response under conditions of urgency in China (Perry, 2019; Van Rooij, 2006), affect performance at the firm level. We show that pollution reductions during the inspections are striking and similar in magnitude to the $SO_2$ reductions that occurred at power plants when a recent round of new emissions standards were implemented (Karplus et al., 2018). After crackdowns end, we find that $SO_2$ pollution gradually returns to prior levels. We integrate our findings with the prior empirical literature on crackdowns and show how, in addition to any direct cost a crackdown imposes on its targets, at least two additional elements are important: the cost of reversal and the heterogeneity in agents' accountability. These elements are not considered in prior studies. For instance, Eeckhout et al. (2010) study rotating speeding cameras on Belgian roadways, a setting in which compliance (with speed limits) poses limited cost on drivers, while punishment, conditional on detection, is certain for all agents. Other empirical studies of crackdowns focus on one-time increases in scrutiny, for example, in international banking (Johannesen and Zucman, 2012), policing drug trafficking (Dell, 2015), and fighting corruption (Di Tella and Schargrodsky, 2003), which limits intertemporal shifting of illicit activities. In China, by contrast, agents' (power plants) probability of punishment has been hypothesized to vary by level of government oversight (Eaton and Kostka, 2017) and crackdowns are short lived, relative to the payback period for permanent equipment upgrades.

Second, we use firm response patterns to diagnose the organizational origins of poor environmental performance in China, contributing to a broader literature on incentives in public bureaucracies (Banerjee, 1997; Rose-Ackerman, 1986; Lipsky, 1980). Post-crackdown reversion to prior pollution levels is consistent with inadequate incentives to undertake cleanup alongside productive effort, rather than gaps in awareness or knowhow. Our findings raise the question of why, given that the central government presumably had the ability to observe the return to polluting behavior (air quality monitoring was automated during this period), did firm pollution nevertheless revert? Variation in firm accountability allows us to empirically test a phenomenon described in the political science literature on China known as the "central state-owned enterprise (SOE) problem" (Eaton and Kostka, 2017), in which local governments struggle to enforce regulations against state-owned enterprises accountable to national authorities. We find that while central scrutiny is high during crackdowns, reductions are similar across plants; however, once the center withdraws, plants not directly accountable to the city government more quickly return to prior polluting levels. We test and rule out size (plant capacity) as an alternative explanation for the observed relationship between firm oversight and post-crackdown increases in pollution.

Third, we contribute to a literature on the effectiveness of involving citizens in environmental oversight, which has previously focused on advanced industrialized democracies (Jones et al., 1977; Goeschl and Jürgens, 2012; Huet-Vaughn et al., 2018). Prior work has shown how activists and interest groups can permanently induce firms to improve performance (Beierle, 2010; Kagan et al., 2003) or to go "beyond compliance" with environmental regulations (Gunningham et al., 2004). Our findings suggest that the nature of citizen involvement, and its influence on firm environmental performance, can be qualitatively different in authoritarian settings. Temporarily cracking down on polluters and inviting complaints against them may raise perceptions of policy effectiveness, while channeling feedback into circumscribed time frames. At the same time, soliciting citizen input provides the state with information about the nature and intensity of environmental discontent.

Our analysis is structured as follows. In Section 2, we describe our setting, data construction, and empirical approach. We present our main results on the magnitude and duration of crackdown effects in Section 3. Section 4 examines how a firm's linkages to different government levels affects responses. Section 5 focuses on the antecedents and consequences of citizen reporting on polluters during crackdowns. Section 6 concludes.

# 2 Background

## 2.1 Crackdowns in hierarchies: A conceptual framework

We define a crackdown as a pre-announced increase in the stringency of regulatory scrutiny or enforcement. Building on prior literature (Di Tella and Schargrodsky, 2003; Eeckhout et al., 2010; Dell, 2015; Johannesen and Zucman, 2012), several elements are common: there is a targeted behavior (speeding on roadways, corruption, cheating on exams, policy brutality, polluting the environment, laundering money) that has exceeded an acceptable frequency, drawing attention and resources to reduce it. Crackdowns result in an increased probability that targeted activities are detected or punished by a higher authority. In many cases, there is a regulation (e.g., a speed limit, procurement procedures, or environmental standards) that objectively defines acceptable performance.

Beyond this general definition, crackdowns may differ along dimensions that could in principle affect their impact on behavior. As in Johannesen and Zucman (2012), crackdowns can be one-time, unidirectional increases in enforcement, can wax and wane with political cycles (Dell, 2015), or rotate across space and time at various intervals (Eeckhout et al., 2010). Compliance actions also differ in their costs and reversibility, depending on the targeted behavior. For example, drivers need only ease off the pedal in response to an increase in speeding cameras on Belgian roadways (Eeckhout et al., 2010), which modestly raises the cost of travel but does not undermine it altogether. Given that speeding is readily measurable and attributable to individual drivers, detection of violators is virtually assured, removing uncertainty over whether costs will be incurred. All agents in this example have a similar relationship to the state and are equally vulnerable to scrutiny. Moreover, there is essentially no cost to speeding up again once past the cameras. It is therefore not surprising that the authors find crackdowns deter speeding with limited spatial and temporal leakage to non-covered periods.

By contrast, in the cases of new pressure to reduce drug trafficking (Dell, 2015), money laundering (Johannesen and Zucman, 2012), or corruption in procurement (Di Tella and Schargrodsky, 2003), would-be violators see a one-time, permanent increase in the expected cost of their activities. This distinguishes these cases from the speeding case, in which scrutiny is short lived. Cost-minimizing criminals may therefore find it attractive to relocate to other jurisdictions where oversight is more lax, especially if the crackdown threatens their economic viability. Thus differences in marginal abatement cost and duration of the crackdown could explain why spatial spillovers are large for one-time crackdowns on criminal activity but small to non-existent for short-lived, rotating (e.g. speeding) crackdowns.

Our setting, in contrast to other examples studied previously, combines high (and uncertain) costs of either complying or being caught with a short crackdown duration. Here, the pattern of pollution before, during, and after inspections can reveal bottlenecks to effective oversight during non-crackdown periods. We consider three possibilities: (1) crackdowns raise managers' awareness of the importance of environmental protection, (2) crackdowns train managers and local officials how to apply regulations, and (3) crackdowns increase managers' payoff to reducing pollution emissions.[2] If awareness (1) is the only bottleneck, a crackdown would have no effect, because simply possessing information would not enable a firm to act. If training (2) is the gap, we would expect pollution to fall during crackdowns and remain at a low level, as local officials and managers learn how to undertake cleanup. If weak incentives (3) are the problem, pollution would fall during crackdowns when scrutiny is high, but return to prior levels afterwards as the probability of detection and/or punishment falls. In this scenario, reductions could spill over into non-crackdown periods if firms do not perfectly observe changes in the probability of detection. The pace of any reversion toward baseline levels would reflect the updating of this probability.

This analysis further explores the consequences of heterogeneity in firm accountability to various authorities in China's governing hierarchy. By studying the extent and timing of plant responses to crackdowns, we can infer the extent of pressure exerted by their overseers, an approach similar in spirit to inferring the value of firms' political connections using abnormal stock market returns (Fisman, 2001) or of firms' government relationship-building activities by observing perk expenditures (Fang et al., 2018). Observed patterns can thus begin to reveal the dynamic balancing of objectives at different levels of the government hierarchy.

China is an appropriate setting to study how crackdowns work in hierarchies. Ensuring that local actions reflect central objectives has been a centuries-old governance challenge in China, captured by the ancient Chinese proverb, "the mountains are high and the emperor is far away." The crackdown approach dates back to the founding of the People's Republic of China, with earlier analogs in the country's imperial history. During the Qing and earlier Ming dynasties, the Imperial Commissioner (*qinchai dachen* in Chinese) was charged with ensuring common practices were employed throughout China's localities, typically in response to large-scale national disasters or challenges. The approach of mobilizing "work teams" (*gongzuo zu* in Chinese) was later introduced from the Soviet Union and combined with local practices after the People's Republic of China was founded in 1949 (Perry, 2019). Work teams involved dispatching central cadres to localities, often reaching over the intermediate layers of the bureaucracy, to address a pressing governance challenge such as population control, heath and sanitation, corruption, or pollution (Perry, 2019; Van Rooij, 2006). China's recent environmental inspections are a modern example of this approach. Chinese media have likened the current environmental inspections to the Imperial Commissioner (Ma, 2017; Zhi, 2016). Although they have long been an important in the central governance of China's periphery, the effectiveness of crackdowns has never been studied empirically.

[2]We adapt these possibilities from the literature on organizational performance. In particular, we draw on Jan Rivkin's four "tions" (perception, inspiration, motivation, implementation) discussed in Gibbons and Henderson (2012).

## 2.2 China's rotating environmental inspections

China's central government initiated environmental inspections in response to growing concern that pollution was harming human health and undermining public confidence in government. The Central Commission on Comprehensively Deepening Reforms proposed the creation of a "Central Environmental Inspection Team" during their fourteenth meeting on July 1, 2015 (State Council, 2015). The inspection team is under direct control of the Ministry for Environmental Protection (MEP)[3] and parallels the structure of the team that is responsible for the nationwide anti-corruption campaign (Xu, 2017). Inspection teams from the MEP are deployed to cities, where they conduct month-long reviews of local governments' environmental protection efforts. The goal of the inspections is to ensure all provincial-level regions follow the central government's direction when implementing pollution control measures.[4] For the coal power plants in our study sample, this largely involved monitoring plant compliance with emissions concentration standards. The crackdown consisted of five rounds of inspections, starting in December 2015 and ending in late 2017. During these two years, the inspection team covered all 31 provincial-level administrative regions in mainland China [5]. Figure 1 shows the composition of the five inspections rounds. Hebei Province was the only region included in the initial trial round, and each of the subsequent four rounds involved cities in seven or eight provinces.

During their stay (4-5 weeks) in a targeted province, the inspection teams reported lapses in compliance with central environmental requirements, oversaw local rectification efforts, reviewed public complaints, and diagnosed weaknesses in local environmental oversight. Inspectors released results of the inspections to the public on the provincial environmental protection bureau's website and to local newspapers shortly after they became available. As a result of the two-year rotating crackdowns, inspectors investigated over $135,000$ complaint cases, punished over $29,000$ companies and imposed fines totaling 1.4 billion yuan (224 million US dollars). A total of $1,527$ people were detained and almost $18,000$ officials were held accountable. Table 1 summarizes key statistics for the five inspection rounds. When the inspections were launched, it was not clear whether or not they would be repeated. Only after the completion of the first inspection round in December 2017 did the central government announced plans to repeat inspections every few years. Inspection teams were again dispatched in 2018 for a "look back" (*huotou kan* in Chinese) to evaluate progress in addressing violations discovered in the first round, and central officials announced plans to conduct subsequent rounds on a biannual basis.

[3] The Ministry of Environmental Protection was reorganized into the Ministry of Ecology and Environment (MEE) in mid-2018.
[4] We use the term "provinces" to refer to all provincial-level regions, including provinces, autonomous regions and municipalities.
[5] Environmental inspection teams were not dispatched to Taiwan and two special administrative regions (Hong Kong and Macau).

## 2.3 Inspection time line and procedures

China's environmental inspections authorized central officials to directly scrutinize the activities of city-level officials, largely focusing on the environmental protection bureau. This type of intervention in China's decentralized government system is otherwise rare, as each administrative level is typically only responsible for the performance of the layer directly below it. Guidelines for the conduct of inspections were laid out in the "Regulations on Environmental Protection Supervision (trial version)," proposed July 1, 2015. Teams of mostly central and provincial officials were authorized to evaluate performance of local environmental protection authorities and firms at the city and lower levels during the inspection period. The State Council distributed guidelines to city governments around August 2015, before the official launch of the trial round in December 2015.

Inspections proceed in stages. The first stage is known as "Preparation for inspection," which begins approximately two months prior to the start of an inspection. During this period, members of the inspection team are selected, primarily from two agencies: the central Ministry of Environmental Protection and its sub-branches and the General Office of the Communist Party of China (the Central Office) and its personnel arm. The involvement of the Central Office in particular raised the profile of the inspections. Some inspection teams also included journalists and regional environmental protection agency workers. By the end of this stage, the exact details of the on-site inspection plan were announced to the provincial-level government for the first time, no more than six weeks prior to arrival.

The next stage is "On-site inspection," during which the central inspection team locates in the targeted province(s) for approximately five weeks. While locally based, the team conducted their own unannounced inspections of firms and sets up telephone hotlines, mailboxes, and social media channels to receive tip-offs on pollution sources from local citizens. Complaints are passed on to the city environmental protection bureau for verification and follow up, while the central inspection team oversees the process. Once accuracy of complaints is verified, firms could be required to shut down or to rectify pollution, in addition to paying fines and/or facing legal action. Government officials could also be held accountable for firms' regulatory violations.

The on-site inspection period is followed by the "Review and feedback" stage, which is described in the "Environmental Protection Knowledge Manual" (Chengdu Municipal People's Political Consultative Conference, 2006). Teams evaluate the overall performance of the cities included in each round and submit their findings in a report to each provincial government. Reports evaluate local regulatory enforcement capabilities and described areas needing improvement. Some of the common problems found were: insufficient implementation of environmental regulations, a lack of an approach to evaluate and respond to pollution monitor readings in excess of standards, and weak environmental leadership. After the findings were handed to the provinces, cities entered the "Rectification and enforcement" stage. Within 30 days, each city government was required to develop and submit a "rectification plan" to the State Council. The plan was to include a detailed response to every finding in the inspection team's report, for example, by elaborating on how the city would address problematic polluters and improve local environmental governance practices. Once the plan was approved by the State Council, provincial leaders were required to publish the "rectification plan" and to provide updates on its implementation status to the public.

## 2.4 Data Construction

### 2.4.1 Information on Environmental Inspections

To determine the start and end date of inspections, we rely on public announcements scraped from the MEP (now MEE) website,[6] and corroborate them with the dates reported by various media outlets.[7] As firms may have learned of an impending inspection during the period between central selection and the team's arrival, we informally asked officials and plant operators in Hubei and Shandong how far in advance they were aware of the inspections. We found that the earliest point at which any of them was aware of an inspection was six weeks ahead, although most were not informed until a few days in advance of the team's arrival. We therefore define a pre-inspection "Announce" period that spans the six weeks prior to the inspectors' on-site arrival to detect any early divergence in treated plants' polluting behavior. Preparation in response to the threat of closer scrutiny has been observed in other settings. For instance, in Keohane et al. (2009), highly polluting plants in the U.S. reacted to the threat of being named in a lawsuit by lowering emissions. Similarly, French plants increased their $CO_2$ emissions once it was clear they would be included in the region's emissions trading system (Colmer et al., 2018), presumably because the number of free permits they were entitled to depended on emissions prior to the start of the program.

### 2.4.2 $SO_2$ emissions

We focus on emissions of $SO_2$ for several reasons. $SO_2$ is a major pollutant that causes cardiovascular and respiratory disease and contributes to the formation of ambient particulate matter, which when inhaled has severe human health consequences. Monitoring of $SO_2$ in China is well established, and during our sample period coverage of $SO_2$ is comprehensive across space and time. $SO_2$ is a short-lived pollutant, and thus ambient measurements near power plants are a good proxy for plant emissions. We assemble hourly air quality data for $SO_2$, measured as ambient concentration ($\mu g/m^3$) at the level of individual monitors nearest to coal power plants. We use monitor-level data on ambient pollution levels, which are directly related to human health impacts and are available for all coal power plants.

The China National Environmental Monitoring Center provides a publicly-available data plat-

[6] Detailed information on the timing of inspections can be accessed at `http://www.mee.gov.cn/home/rdq/jdzf/zyhjbhdc/dcjz/`.
[7] We compiled reports from multiple news outlets including *China Daily*, Sina news, and Wangyi 163 news.

form that publishes hourly pollutant concentrations at all monitoring stations.[8] Cities typically install multiple monitors, with an average of five monitors per city. Our data set spans the period from May 2014 to May 2018, which allows us to evaluate pollution at the plant level before, during, and after the inspections. To reduce noise, all hourly air quality measures are averaged at the weekly level. Missing observations, which correspond to periods when a monitor was not operational (e.g., due to routine maintenance), are dropped when computing weekly averages for individual monitors. We examine the inspections' effects in city-level data for all provinces, and plant-level data for six provinces in which data were available and complete: Hebei, Henan, Hubei, Guangdong, Shanxi and Shandong. Our sample is comprised of 973 plants in 89 cities, and covers all five inspection rounds.

#### 2.4.3 Empirical approach

We use the exogenous timing of inspections to identify average effects on $SO_2$ pollution around targeted firms. In order to attribute changes to the central inspection team's arrival, the selection and timing of inspections should be uncorrelated with firms' environmental performance. This is plausible for two reasons. First, all provinces were inspected, regardless of environmental record, and timing was chosen for reasons orthogonal to pollution patterns, such as regional diversity within each round and efforts to limit local government anticipation of inspection arrivals. Second, central officials internally decided the upcoming round of provinces several weeks in advance and withheld this information from localities until a few days before inspectors arrived (our empirical specification allows for the possibility that some plants may have been notified up to six weeks in advance). Thus even plants in regions included in the final round, which might have otherwise foreseen inspections, would not have been able to anticipate the exact grouping of provinces selected or the timing.

Even if the timing of inspections is plausibly exogenous, compositional differences in cities and/or power plants included in each round may complicate comparisons between treatment and control groups. To examine this concern, we perform several tests. First, we ask if firms in the treatment and control groups in our six-province sample are balanced on observable characteristics. We find that treated firms tended to be in more densely populated cities in the Trial Round (Hebei province only) and less densely populated areas in Round 4 (see Appendix Table A.1). Second, we predict inclusion in different rounds using a multinomial logit model (see Appendix Table A.2) as well as linear probability and logit models (Appendix Table A.3), using all cities in the 31-province sample. We again find that population density predicts inclusion in the Trial Round and Round 4, with coefficients directionally similar to the six-province sample results. Other covariates do not predict inclusion in the treatment group.

To address these compositional concerns across rounds, we implement a data preprocessing

[8]The platform can be accessed at `http://106.37.208.233:20035/`.

strategy, entropy balancing (Hainmueller, 2012), to improve the comparability of the treatment and control groups.[9] In Table 2, columns (1) and (2) reveal higher baseline levels of $SO_2$ pollution around treated plants compared to control plants. These differences could plausibly be attributed to variation in industry composition, such as ownership, size, and the installation status of pollution control equipment across rounds (see Table 4). We therefore calibrate each observation's weight to ensure re-weighted plants in treated cities and those in control cities are balanced on covariates. We balance on the first-order covariate, but the results are robust to balancing on second and higher-order moments of the covariate distributions. We include the following list of covariates in the entropy balancing routine: (i) city characteristics of per-capita income and population level; (ii) firm characteristics of geographical location, revenue share, company age, ownership and oversight level; and (iii) $SO_2$ concentrations in the baseline period (12 to 7 weeks prior to the arrival of the central inspection team). Balance tests in Appendix Table A.4 show observed company characteristics and baseline pollution levels are not statistically different between treatment and control firms in the entropy balanced sample for all five inspection rounds. Pretrends are no longer visible in the entropy-balanced sample (Table 2, columns (3) and (4)).

# 3 Main Results

## 3.1 Visual Evidence

To examine how crackdowns affect $SO_2$ pollution, we begin by visually inspecting changes in ambient $SO_2$ measurements in cities while the inspectors are present. For this comparison, we make use of average $SO_2$ pollution levels for all cities in China. Figure 2 compares logged $SO_2$ pollution levels before, during, and after an inspection in targeted (treated) and non-target (control) cities. Plots are centered on the start of the inspection period (vertical line at week 0) in a city. Weekly observations represent the unweighted average of hourly $SO_2$ measures, which are subsequently averaged at the city level by treatment status. The lighter shaded area corresponds to the six-week period between when inspections are announced and inspectors arrive on site. On average, treated cities (solid line) show visual evidence of $SO_2$ reductions during the "Announce" period (lighter shaded area), while $SO_2$ in control cities (dotted line) appears to slightly increase. During the on-site inspection period (subsequent darker shaded area), the reduction in pollution in treated versus control cities is readily apparent. This gap persists from beginning of the announcement period until approximately eight weeks following the completion of on-site inspections, when they coverage again, as shown in the longer post-period in (b).

The remainder of our analysis focuses on observations of ambient $SO_2$ pollution at monitors nearest to power plants in our six-province sample. We show that the nationwide pattern described

[9] We use the STATA package "ebalance" developed by (Hainmueller and Xu, 2013). The package can be accessed at `https://web.stanford.edu/~jhain/Paper/JSS2013.pdf`.

previously in Figure 2 is replicated in Appendix Figure A.1 for power plants in our six-province sample. Furthermore, to address the concern that already-treated and never-treated provinces will provide different controls, we resolve these two subgroups within the control plant category and show that $SO_2$ in already-treated control cities is similar before and after but lower during inspections compared to never-treated control cities (see Appendix Figure A.2). By including both types of control cities, our estimates provide a lower bound on the effect of inspections in treated cities. To evaluate how well monitor measures capture plant emissions concentrations from a proximate facility, we compare ambient $SO_2$ concentration at monitors nearest a plant with plant-specific measures (from continuous emission monitoring systems installed on plant smokestacks) for Henan province. Appendix Figure A.3 shows a strong correspondence between the monitor and stack measurements for plants, suggesting our monitor measure is an acceptable proxy for direct emissions from power plants.

### 3.2 Regressions and Event Study

To obtain the impact of an inspection on plant-level $SO_2$ emissions, we estimate the following difference-in-differences (DID) regression specification:

$$
\begin{aligned}
\ln(\mathrm{SO}_{2it}) = \alpha + \delta(\mathrm{Announce}_{it}) + \lambda(\mathrm{Onsite}_{it}) + \xi(\mathrm{Post}_{it}) \\
+ \sigma(\mathrm{Elsewhere}_{it}) + \gamma_i + \lambda_t + \epsilon_{it} \quad (1)
\end{aligned}
$$

Here, our dependent variable is the ambient pollution level reported by the monitor located nearest to each coal power plant in our six-province sample. $SO_{2it}$ is plant $i$'s average $SO_2$ concentration ($\mu g/m^3$) in week $t$. $\mathrm{Announce}_{it}$ equals 1 one to six weeks before central inspection team arrives, and is otherwise zero. $\mathrm{Onsite}_{it}$ equals 1 during the inspection period (when the central inspection team is physically on site), and is otherwise zero. $\mathrm{Post}_{it}$ equals 1 in the post period (after the central inspection team leaves the province), and is otherwise zero, for 12 weeks in the short-run estimates and 36 weeks in the long-run estimates. $\mathrm{Elsewhere}_{it}$ equals 1 if the inspection team is physically on site in another province, which occurs at least three months after the inspection ends in the focal province (and is zero otherwise). Changes in $SO_2$ in each phase are expressed in log points and relative to the average baseline period level (7-12 weeks prior to inspection). Power plant fixed effects $\gamma_i$ control for time-invariant differences in $SO_2$ pollution around plants, due for instance to local geography, climatic conditions, or electricity demand. We include week fixed effects $\lambda_t$ for $SO_2$ concentration changes due to seasonality of weather or electricity demand, and year fixed effects to capture changes in plant technology or $SO_2$ policy over time that are common to all power plants. Standard errors are clustered at the city level, given that the shock is directed at the city government and its environmental protection bureau, which oversee regulatory implementation at local firms.

Table 3 summarizes the estimated effects of inspections for a short-run (12-week), medium-run (24-week), and long-run (36-week) post-inspection horizon. When inspection teams are on-site, $SO_2$ levels at plants drop by 25-27% in log points (entropy-balanced sample). This is a substantial reduction in average ambient $SO_2$, relative to baseline levels. While the effect magnitude is slightly lower, there is no statistically-significant difference in the coefficient magnitudes between the entropy-balanced and original samples, which are presented side-by-side in Table 3.[10] After the crackdown ends, reductions gradually attenuate, returning to baseline levels by 24-36 weeks after the inspection team has left (see estimates in columns 7 and 8; summing the coefficient on Post and Post (24-36 wks) in column 8 gives a reduction in the latter third of the post period that is no different from zero, relative to baseline levels. The fact that reductions attenuate and eventually return to baseline favor incentive alignment over knowledge transfer as the behavioral mechanism by which the crackdown reduces pollution. The positive and moderately-significant (at the 5% level) coefficient on "Elsewhere" could reflect the fact that a subset of the control cities have lowered their emissions in response to the start of on-site inspections.

To confirm the directionality of $SO_2$ trends within each phase, we further visualize the effect of a crackdown in two ways. First, we examine the effect of a crackdown on the distribution of city average pollution around the treated plants during the announce, on-site, and post crackdown periods, shown in Figure 3. The narrowing of the distribution of $SO_2$ emissions, and in particular the thinning of the right tail, suggests that the dirtiest plants cleaned up the most, resulting in a reduction (leftward shift) in average $SO_2$ pollution at the mean. There is only a slight visual difference between the distribution of $SO_2$ pollution before and after crackdowns, with greater mass immediately to the right of the mean, suggesting that the crackdowns had no lasting effect.

Second, we resolve the effects of inspections at the weekly level in an event study. Figure 4 shows how the announcement and on-site period is characterized by reductions relative to the baseline period (the omitted week is -7, one week before the earliest point of announcement). These reductions attenuate in the weeks following the on-site period, and drift back to near- or even (visually) above-baseline levels by week +12. Parallel trends in the treatment and control groups, which is necessary for the validity of the DID, hold prior to the inspection period, as shown by the insignificant coefficients on the baseline weeks (-8 to -11), reproduced in the regression in Table 2, columns (3) and (4). The effect of an inspection elsewhere has already been controlled for in the regression used to generate the average effects of the inspection by week in the event study.

Our data further allow us to observe the mechanism(s) by which firms reduced pollution during crackdowns. Over the short (multi-week) time frames we use to resolve effects of crackdowns, firms had limited options to reduce $SO_2$ emissions. One option was to operate an already-installed $SO_2$

[10] Results are further robust to removing the six plants that are permanently shut down after the on-site period (see Appendix Table A.5), which would be expected to bias post-period reductions downward.

emissions control device (or "$SO_2$ scrubber"). Approximately 80% of the firms in our sample had $SO_2$ scrubbers installed prior to the arrival of inspectors (for a breakdown of scrubber coverage, see Table 4). When working properly, scrubber operation results in near-complete removal of $SO_2$ pollution from a plant's waste gas stream. Running a scrubber requires variable inputs of labor and energy and is thus costly to firms. A second option for plants to curb $SO_2$ emissions is to reduce output. As a proxy for electric power production, we focus on another pollutant, $NO_X$, which is formed when nitrogen reacts with ambient air during combustion and thus scales with plant output (unlike $SO_2$, it is not related to the chemical composition of the fuel).

Table 5 shows how $NO_X$ levels change before, during, and after the inspections. We use the entropy-balanced sample but exclude plants that have $NO_X$ scrubbers installed (204 plants) in order to ensure that observed changes are due only to adjustments in plant output, and not end-of-pipe $NO_X$ removal. We find that on average plants reduce $NO_X$ (electricity output) by 3-7% during the on-site phase of the inspection. However, the lowering of output can only partially explain the large reductions in $SO_2$ observed during the inspection period, and therefore plants must be operating $SO_2$ scrubbers operation to achieve deeper pollution reductions during inspections.[11] Thereafter output increases above baseline levels for nearly six months, by 3-6%, suggesting that plants may have deferred productive activity. Power plants in China are compensated according to annual production schedules. Shifting output to periods with lower environmental scrutiny is consistent with behavior observed in other settings in which firms face quotas or deadlines that affect performance evaluation (Oyer, 1998, 2002).

## 4 Government oversight and plant responses to crackdowns

State-owned firms in China are differentiated by their accountability to their respective levels of China's governing hierarchy, as shown in Figure 5. We introduce heterogeneity by differentiating their accountability to "upper" levels (provincial and national governments, here an "Upper SOE," shown in the figure as black circles), which outrank the city government, and "lower" levels (city and below, here a "Lower SOE," shown as a white circle), which are subordinate to the city government. City environmental protection bureaus have been found in prior work to face greater difficulty in enforcing violations at plants that are not directly accountable to the city through oversight ties, a phenomenon known as the "central SOE problem" (Eaton and Kostka, 2017). We are able to examine the role of rank empirically, by differentiating responses around state-owned plants accountable to various levels of the government hierarchy, as well as the responses of private plants (gray circle), which are not structurally accountable to the government through oversight ties.

[11] In theory, plants could also switch to low sulfur coal use, however, by 2015 plants in China were already using low sulfur coal, and this shift offers more limited $SO_2$ reduction potential compared to running scrubbers.

We ask whether the effect of an inspection is differentiated by a firm's accountability within the hierarchy. During the on-site period, we do not see a difference in the reductions achieved by Upper SOEs relative to other firm types (see column (2) of Table 6). However, Table 6 shows that firms outranking the local government revert faster once the central inspection team leaves, indicated by the coefficient on eleven weeks post inspection interacted with Upper SOE (see column (3)). This effect attenuates thereafter, as shown by the lack of significance of the coefficients on Upper SOE interacted with the later two-thirds of the post-period, shown in columns (4) and (5), respectively.

When we narrow the sample to Upper SOEs only and interact the post inspection period with scrubber status in Table 7, we find that Upper SOEs with scrubbers revert fastest during the post period (column (2)) relative to those Upper SOEs that do not. This effect is less pronounced for other types, especially lower SOEs that are directly accountable to the city government. Private firms with scrubbers also see pollution rise sharply in the post-inspection period relative to those that lack control equipment. It is difficult for regulators to observe when a firm ceases scrubber operation and $SO_2$ is invisible, thus the likelihood of detection during the post period was plausibly low. Our results are consistent with a scenario in which Upper SOEs with scrubbers lowered their expectations about the likelihood of detection and/or punishment following an inspection, while lower SOEs did not, at least initially. Given that Upper SOEs tend on average to be larger firms, we test size as an alternative explanation for the pattern we observe. As shown in Table 8, the relationship between scrubbers and reversion is statistically significant for all size categories. While the magnitude of effects increase with size, size alone cannot explain why firms accountable to the city government do not revert as rapidly as centrally-controlled firms.

## 5 The role of citizen complaints

We turn to examine the role of citizen participation during the inspections. Because citizens remain once inspectors leave, their complaints could plausibly prolong a firm's attention to reducing pollution. To understand whether involving citizens increased and/or extended the impact of inspections, we further consider an important element of the crackdown: citizen reporting on polluter behavior. When the central inspection teams were present, they set up mailboxes, social media channels, and hotlines to collect citizen complaints, and required the local environmental protection bureau to respond to all of them. This proved very taxing for environmental bureau officials, resulting in exhaustion and even death for some employees (Zhihu, 2017). Complaints ranged widely, targeting everything from noise to air and water pollution discharges by firms in a wide range of industries. Following a complaint, several steps could be taken against an offending firm: inspectors could require that the problem be rectified, the firm could be shut down, and/or officials in the local environmental protection bureau could be held accountable. All complaints were investigated and, while less than 10% were found to be false, others resulted in corrective actions against firms during the crackdown.

Engaging citizens might at first appear to be an unlikely feature of an authoritarian approach to environmental cleanup. Given this, why did the Chinese state establish this dedicated feedback channel? There are many examples of how authoritarian regimes engage citizens, from online participation portals (Truex, 2017) to elections (Miller, 2015). In the Chinese context, citizen reporting may have served several purposes. First, it may have expanded state capacity to detect both violations and citizen discontent, expanding monitoring alongside enforcement. Second, it may have temporarily granted citizens agency in fighting environmental pollution in their immediate vicinity, in the process raising their awareness of the state's corrective efforts. Third, public announcements of how complaints were addressed may have signaled the government's responsiveness. We examine empirically what predicts a firm's receiving a complaint, and ask to what extent a complaint directed at a plant translated into lasting environmental improvement.

### 5.1 Complaint data collection

We collected public complaints about firms by scraping the text of electronic records from the provincial environmental protection bureau (PEPB) websites, focusing on complaints against coal power plants. Each entry includes: a full description of the formal complaint, the date when the complaint was made, details of the case, and the local government response, e.g. shutdown of a polluting plant, detention of violators, and punishment of officials. We provide the text of a sample complaint for a coal power plant in Chinese and English in Appendix Table A.6. The complaint status is updated continuously online with information such as the date of closure and disciplinary action against targeted officials.

To generate an overview of what inspections accomplished, we further summarize information on all complaints received, which is publicly posted on the MEP website[12]. This includes the total number of cases closed for each province, the number of firms ordered to rectify errant practices, the number of firms ordered to shut down, the number of firms facing litigation, any fine imposed on the polluters, the number of individuals detained, the number of officials interviewed, and the number of officials disciplined. As shown in Table 1, on average, each province received around 3,000 complaints (a detailed summary by province is included in Appendix Table A.7). The smallest number of complaints filed was around 500 for Ningxia Hui autonomous region (a less populated and less developed province in Western China), while Sichuan had the largest at nearly 9,000 complaints. The number of complaints increased with each subsequent inspection round.

[12] Accessible at `http://www.mee.gov.cn/home/rdq/jdzf/zyhjbhdc/fkqk/`.

## 5.2 Impact of citizens complaints

We examine the effectiveness of allowing citizens to complain about polluting firms, focusing on three questions. First, we ask what predicts whether or not a coal power plant receives a complaint by a citizen? In other words, do citizens successfully report the plants that polluted more in the baseline period? Second, we ask how do any $SO_2$ reductions at firms receiving complaints compare to the average plant in a city? Third, we ask if these effects persist longer, compared to those at plants that did not receive complaints in the same city? Among the firms that received complaints, a subset were either rectified, shut down, or officials were held accountable (summarized by ownership in Table 9). We examine each of these questions in turn.

Predictors of a plant receiving a complaint are shown in Table 10. High baseline $SO_2$ does not by itself predict a complaint. A higher per-capita income level in the city positively predicts receiving a complaint, which is consistent environmental awareness growing with income (Ito and Zhang, 2016). Moreover, citizens in wealthier cities may be more aware of the health consequences of degraded air. Population density negatively predicts complaints, perhaps because citizens are unable to visually attribute pollution to a particular firm in densely populated urban or industrial areas. Plants that later receive complaints disproportionately lowered their $SO_2$ levels during the Announce period, perhaps because they had above-average $SO_2$ emissions at baseline and anticipated greater scrutiny during the inspection. State oversight, upper or lower, is not systematically correlated with receiving complaints.

We redraw the distribution of plant pollution (shown in Figure 3) to differentiate between the behavior of complained and non-complained plants during the on-site period, shown in Figure 6. The main difference between the former and latter groups is that plants receiving complaints do not show a second mass in the right (high $SO_2$) tail of the distribution. In the group of plants not receiving complaints, this mass is visible between values of 3.5 and 4.5 on the $\log(SO_2)$ scale. It is impossible to tightly attribute the distribution of $SO_2$ to the fact that plants received complaints, because there may be unobservable differences between plants that do/do not receive complaints (e.g., economic status of the surrounding citizens).

Table 11 shows the partial effect of a complaint on the average reduction around plants in a targeted city, which is generated by running the difference-in-differences regression on complained (treated) and non-complained (control) plants in the same city. During the on-site period, plants receiving complaints reduce $SO_2$ more on average compared to those that do not receive complaints (7.5% additional reduction in log points, significant at the 5% level). However, during the post period, plants receiving complaints show no sign of maintain reductions longer or reducing further, and instead revert faster to prior pollution levels (see coefficients on the interaction of Post and Complaint in columns (3) and (4)). Differentiating between upper and lower SOEs reveals slightly higher reductions among the upper SOEs (consistent with earlier findings), but the difference is not statistically significant.

## 6 Conclusion

This analysis has examined the effectiveness of crackdowns in overcoming weak regulatory enforcement in a hierarchy under conditions of urgency. We focused on one example, environmental inspections in China, which have been widely credited with addressing the country's severely degraded air. Our findings quantify the effects of China's environmental inspections on one major air pollutant ($SO_2$) over time. Pollution reductions are found to be large (25-27%) but ultimately return to baseline levels, underscoring the importance of resolving effects in high frequency (weekly) data. Our estimates suggest that crackdowns had no long-term effect on environmental performance. Weak cleanup incentives, and not a lack of awareness or knowhow, are consistent with the pattern we observe.[13]

Our findings can be interpreted alongside prior work on crackdowns to generalize several additional factors that influence effectiveness. How the cost and reversibility of firm responses interact with a crackdowns' time horizon appear to be important determinants of whether the targeted behavior is deterred or simply displaced in time or space. Duration and expectations about the frequency of a crackdown's recurrence may interact with decisions about whether to implement a (less costly) short-term or (potentially more costly) long-term solution. In the case of China's environmental inspections, we found that firms employed short-term measures—turning scrubbers on, or temporarily restricting electricity output—that were relatively easy and rewarding to reverse. Instead of short-term pressure, tougher requirements to install scrubbers and incentives for their continuous operation are likely to be more effective in achieving pollution reductions.

We further show that norms of accountability between firms and their oversees affect $SO_2$ reduction patterns once an inspection ends. The differential rates of reversion may reflect an updating of expectations about the likelihood of punishment by the remaining (local) authority once the center has left. Managers of upper SOEs may have been more confident that they could escape detection or punishment, and returned to polluting sooner, while lower SOEs may have had residual uncertainty about the extent of any increased stringency in local government oversight. Our results are consistent with this uncertainty resolving several months after inspections end, when all plants had returned to prior polluting levels. Our results are indicative of a broader administrative problem of localities controlling outranking SOEs. For example, it was reported recently that officials in Hunan Province were afraid of and unwilling to tackle environmental violations by central SOEs (Zhang, 2019). One solution could be for the central government to continuously scrutinize upper SOEs directly on an ongoing basis, and consistently punish violations. Indeed, when the second full round of inspections began in 2019, it included direct inspection of two central

[13] Our results do not imply that pollution stayed the same or worsened over the period of our study. Indeed, when we examine the coefficients on the year fixed effects in Table 3, we find double-digit reductions on average every year from 2016 and 2018, relative to 2015. These reductions have been attributed to the introduction of China's ultra-low emissions standards, which require substantial reductions in emissions of $SO_2$ and other pollutants by 2020. Our results suggest that against the backdrop of ongoing nationwide pressure to reduce air pollution, environmental inspections did not contribute to this long-run change.

SOEs (China Minmetals Corporation and China National Chemical Corporation) in addition to the geographical targeting of the first round. Ongoing scrutiny of firms outside of inspection periods is now possible with the MEE's extensive network of environmental monitors and continuous emissions monitoring systems, which is likely to lower the costs of real-time oversight.

If inspections were not effective in a permanent sense, why did the central government initiate them? We offer three possible explanations. First, the center may have been serious about cracking down on local regulatory lapses, but crossing multiple layers of the hierarchy to punish firms is challenging. Only when the center declared a crackdown and directed resources to a subset of localities was it able to convey this message. Meanwhile, firms may have perceived crackdowns as a one-time experiment, leaving them with little incentive to develop permanent cleanup strategies. At the conclusion of the first round, the government announced that crackdowns would be repeated, first for a subset of provinces and later for all in a full-fledged second inspection round. Moving from a one-time experiment to a repeated game may change firm responses, an important area for future study. Second, the center may have viewed crackdowns as a way to gather information from citizens on the nature and extent of local environmental problems, as well as discontent, in order to better direct scarce enforcement and public relations efforts. Third, the crackdown itself may have enabled the state to covey the seriousness of its efforts to citizens, serving to make visible and tangible the government's "War on Air Pollution," given that other measures (such as tougher emissions standards for plants) involve less visible changes.

Our study further offers insight into why and how authoritarian regimes engage their citizenry. Allowing citizens to report polluters may strengthen the monitoring capabilities of the state during crackdowns, revealing local polluters to central authorities and enhancing the credibility of inspectors. At the same time, citizen engagement may increase the legitimacy of the state, by increasing perceptions of its effectiveness among the broader populace. The media's likening of inspections to organizational approaches used in imperial China may only strengthen this perception. The inspections could thus shore up legitimacy in a time of (environmental) crisis—an important benefit for leaders in an authoritarian regime. These benefits could accrue to the crackdown's originators, even if there is no lasting effect on pollution. However, the durability of the inspection approach is unknown. Legitimacy benefits to the central leadership may erode if citizens discover that pollution reductions do not last.

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## References


Banerjee, A. V. (1997). A Theory of Misgovernance. *Quarterly Journal of Economics 112*(4), 1289–1332.

Beech, H. (2013). Beijing Pollution: So Bad, Even Government Admits There's a Problem. *Time*.

Beierle, T. C. (2010). *Democracy in Practice: Public Participation in Environmental Decisions*. New York, NY: Taylor & Francis.

Blackman, A., Z. Li, and A. A. Liu (2018). Efficacy of Command-and-Control and Market-Based Environmental Regulation in Developing Countries. *Annual Review of Resource Economics 10*(1), 381–404.

Chen, Y., G. Z. Jin, N. Kumar, and G. Shi (2012). Gaming in air pollution data? lessons from china. *The BE Journal of Economic Analysis & Policy 12*(3).

Chengdu Municipal People's Political Consultative Conference (2006). Environmental protection knowledge manual.

Colmer, J., R. Martin, M. Muûls, and U. J. Wagner (2018). Emissions Trading, Firm Behavior, and the Environment: Evidence from French Manufacturing Firms (NBER Conference Paper).

Dell, M. (2015). Trafficking networks and the mexican drug war. *American Economic Review 105*(6), 1738–79.

Di Tella, R. and E. Schargrodsky (2003). The Role of Wages and Auditing during a Crackdown on Corruption in the City of Buenos Aires. *The Journal of Law and Economics 46*(1), 269–292.

Duflo, E., M. Greenstone, R. Pande, and N. Ryan (2018, nov). The Value of Regulatory Discretion: Estimates From Environmental Inspections in India. *Econometrica 86*(6), 2123–2160.

Eaton, S. and G. Kostka (2014). Authoritarian environmentalism undermined? Local leaders' time horizons and environmental policy implementation in China. *The China Quarterly 218*(1), 359–380.

Eaton, S. and G. Kostka (2017). Central protectionism in china: The 'central soe problem' in environmental governance. *The China Quarterly 231*, 685–704.

Ebenstein, A., M. Fan, M. Greenstone, G. He, and M. Zhou (2017). New evidence on the impact of sustained exposure to air pollution on life expectancy from China's Huai River Policy. *Proceedings of the National Academy of Sciences of the United States of America 114*(39), 10384–10389.

Eeckhout, J., N. Persico, and P. E. Todd (2010). A Theory of Optimal Random Crackdowns. *American Economic Review 100*(3), 1104–1135.

Fang, H., Z. Li, N. Xu, and H. Yan (2018). In the Shadows of the Government: Relationship Building during Political Turnovers (Working Paper).

Fisman, R. (2001). Estimating the value of political connections. *American Economic Review 91*(4), 1095–1102.

Fisman, R. and Y. Wang (2017). The distortionary effects of incentives in government: Evidence from China's "death ceiling" program. *American Economic Journal: Applied Economics 9*(2), 202–218.

Gibbons, R. and R. Henderson (2012). What Do Managers Do? Exploring Persistent Performance Differences among Seemingly Similar Enterprises. In R. Gibbons and J. Roberts (Eds.), *Handbook of Organizational Economics*, Chapter 17, pp. 680–731. Princeton, New Jersey: Princeton University Press.

Goeschl, T. and O. Jürgens (2012). Environmental quality and welfare effects of improving the reporting capability of citizen monitoring schemes. *Journal of Regulatory Economics 42*(3), 264–286.

Greenstone, M. and R. Hanna (2014, oct). Environmental regulations, air and water pollution, and infant mortality in India. *American Economic Review 104*(10), 3038–3072.

Gunningham, N., R. A. Kagan, and D. Thornton (2004). Social license and environmental protection: why businesses go beyond compliance. *Law & Social Inquiry 29*(2), 307–341.

Hainmueller, J. (2012). Entropy balancing for causal effects: A multivariate reweighting method to produce balanced samples in observational studies. *Political Analysis 20*(1), 25–46.

Hainmueller, J. and Y. Xu (2013). Ebalance: A stata package for entropy balancing. *Journal of Statistical Software 54*(7).

Huet-Vaughn, E., N. Muller, and Y.-C. Hsu (2018). Livestreaming pollution: A new form of public disclosure and a catalyst for citizen engagement? Working Paper 24664, National Bureau of Economic Research.

Ito, K. and S. Zhang (2016, jun). Willingness to Pay for Clean Air: Evidence from Air Purifier Markets in China.

Johannesen, N. and G. Zucman (2012). The End of Bank Secrecy? An Evaluation of the G20 Tax Haven. *American Economic Journal: Economy Policy 6*(1), 65–91.

Jones, B. D., S. R. Greenberg, C. Kaufman, and J. Drew (1977, mar). Bureaucratic Response to Citizen-Initiated Contacts: Environmental Enforcement in Detroit. *American Political Science Review 71*(1), 148–165.

Kagan, R. A., N. Gunningham, and D. Thornton (2003, mar). Explaining corporate environmental performance: How does regulation matter? *Law and Society Review 37*(1), 51–90.

Karplus, V. J., S. Zhang, and D. Almond (2018). Quantifying coal power plant responses to tighter $SO_2$ emissions standards in China. *Proceedings of the National Academy of Sciences of the United States of America 115*(27), 7004–7009.

Keohane, N. O., E. T. Mansur, and A. Voynov (2009, mar). Averting regulatory enforcement: Evidence from new source review. *Journal of Economics and Management Strategy 18*(1), 75–104.

Lipsky, M. (1980). *Street-level bureaucracy: dilemmas of the individual in public services*. New York, NY: Russell Sage Foundation.

Ma, X. (2017). Central Environmental Protection Inspection Group Reveals List of "Environmental Protection Imperial Commissioner" Grievances (in Chinese). `http://china.chinadaily.com.cn/2017-04/12/content_28896842.htm`.

McAllister, L. K., B. Van Rooij, and R. A. Kagan (2010). Reorienting regulation: Pollution enforcement in industrializing countries. *Law and Policy 32*(1), 1–13.

Miller, M. K. (2015, may). Elections, Information, and Policy Responsiveness in Autocratic Regimes. *Comparative Political Studies 48*(6), 691–727.

Oyer, P. (1998). Fiscal Year Ends and Nonlinear Incentive Contracts: The Effect on Business Seasonality.

Oyer, P. (2002, jul). A Theory of Sales Quotas with Limited Liability and Rent Sharing. *Journal of Labor Economics 18*(3), 405–426.

Perry, E. J. (2019). Making Communism Work: Sinicizing a Soviet Governance Practice. *Comparative Studies in Society and History 61*(3), 535–562.

Qu, G., K. Sylwester, and F. Wang (2018, mar). Anticorruption and growth: Evidence from China. *European Journal of Political Economy 55*, 373–390.

Rose-Ackerman, S. (1986). Reforming Public Bureaucracy through Economic Incentives? *The Journal of Law, Economics, and Organization 2*.

Shimshack, J. P. (2014, nov). The Economics of Environmental Monitoring and Enforcement. *Annual Review of Resource Economics 6*(1), 339–360.

State Council (2015). State Council Issues 'Integrated Reform Plan for Promoting Ecological Progress'. `http://www.gov.cn/guowuyuan/2015-09/21/content_2936327.htm`.

Tanaka, S. (2015, jul). Environmental regulations on air pollution in China and their impact on infant mortality. *Journal of Health Economics 42*, 90–103.

Truex, R. (2017, mar). Consultative Authoritarianism and Its Limits. *Comparative Political Studies 50*(3), 329–361.

Van Rooij, B. (2006). Implementation of chinese environmental law: Regular enforcement and political campaigns. *Development and Change 37*(1), 57–74.

Wu, J., Y. Deng, J. Huang, R. Morck, and B. Yeung (2014). Incentives and outcomes: China's environmental policy. *Capitalism and Society 9*(1), A2.

Xu, H. (2017). 'Very Strict' Central Environmental Protection Inspections: Uncovering Problematic Departments One-by-One (in Chinese). `http://finance.people.com.cn/n1/2017/0808/c1004-29455687.html`.

Zhang, S. (2019). CCTV News 1+1: What distinguish the second round of central environmental protection inspections? (in Chinese). `https://news.sina.com.cn/c/2019-07-11/doc-ihytcitm1150756.shtml`.

Zhi, C. (2016). People's Daily says "Environmental Protection Inspection Commissioner" is worth anticipating (in Chinese). `http://opinion.people.com.cn/n1/2016/0812/c1003-28630374.html`.

Zhihu (2017). Memories of the Central Environmental Inspection (in Chinese). `https://zhuanlan.zhihu.com/p/27765906/`.

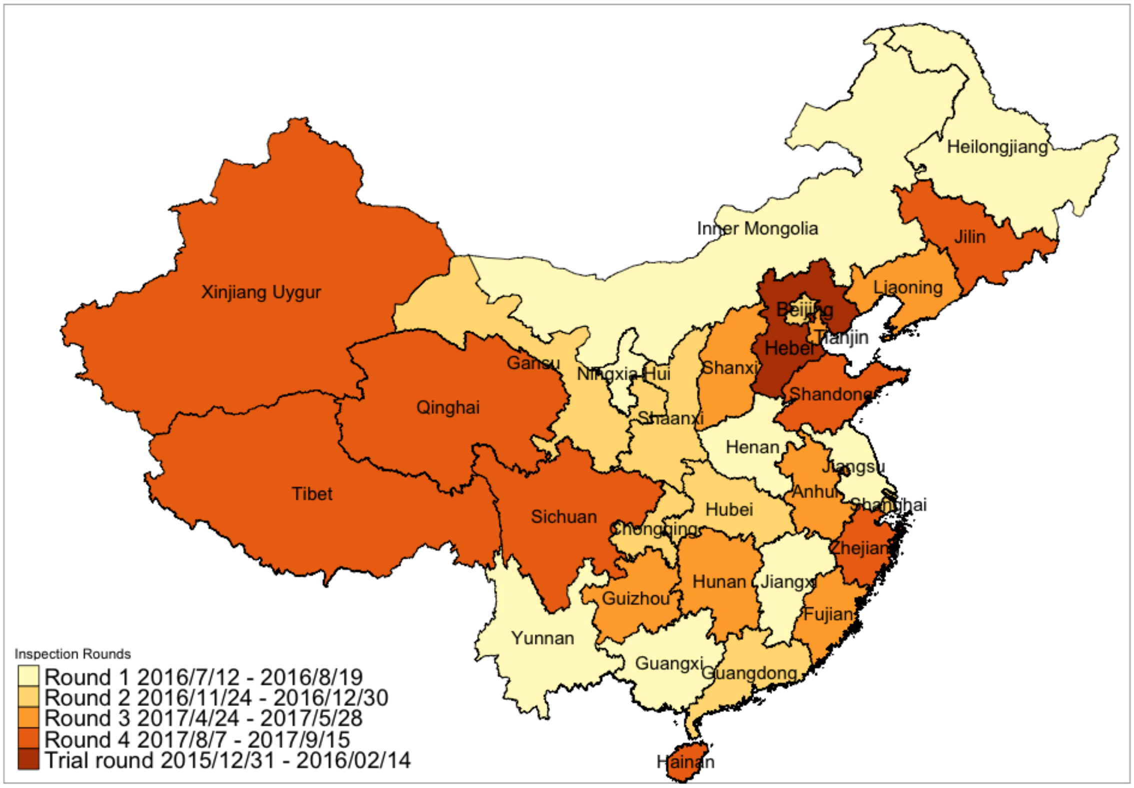
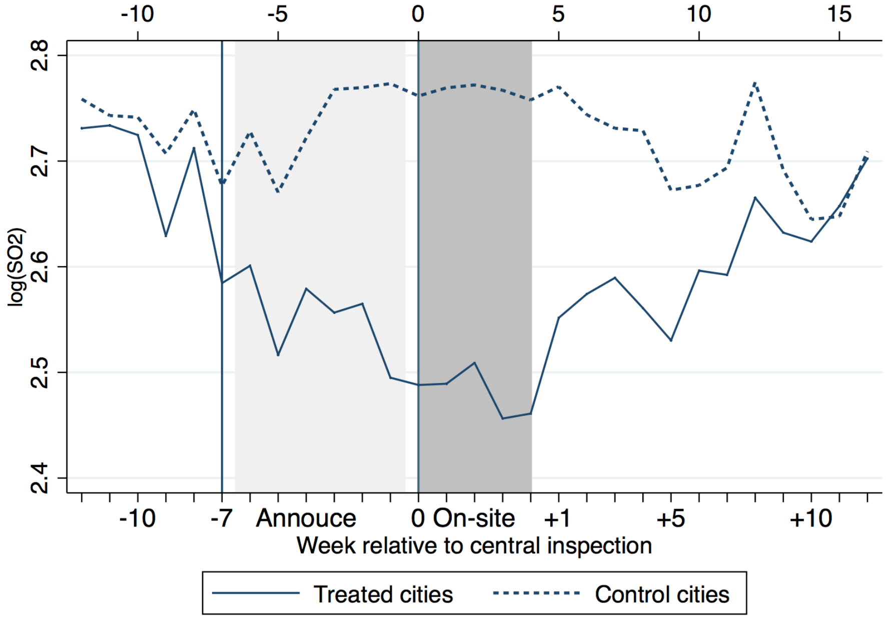
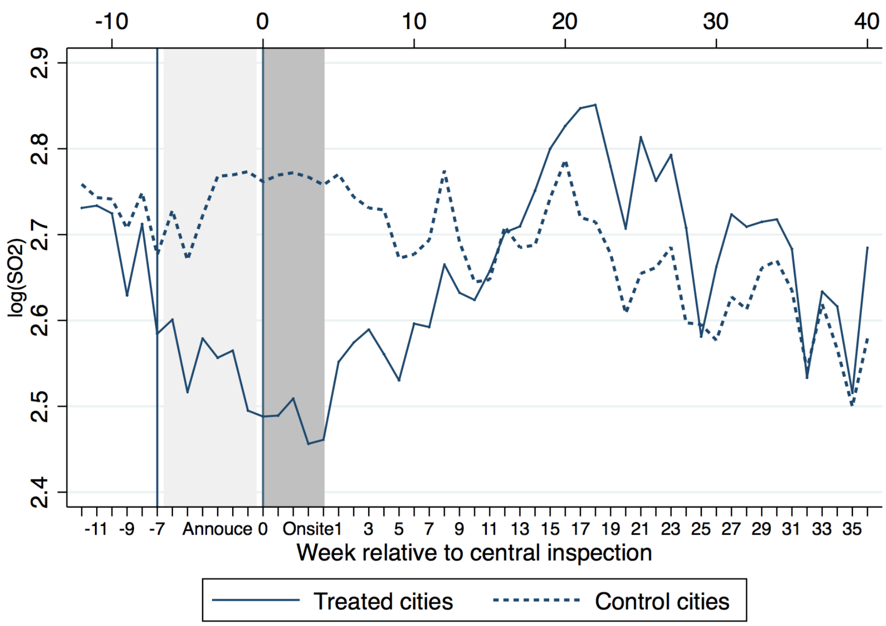



Figure 1. Geographical composition and timing of the five inspection rounds. Trial round includes only Hebei province. Rounds 1-4 cover either 7 or 8 provinces, and do not cover Hong Kong, Macau, or Taiwan.




(a) Short-term (up to 12 weeks post inspection)




(b) Long-term (up to 36 weeks post inspection)

Figure 2. Raw comparison of $SO_2$ concentration in treated and control cities around the inspection event window. The graph is centered on the timing of announcement and inspection in treated cities, while non-target cities serve as a control group in each respective round. Data covers all 31 provincial-level administrative regions in mainland China (excluding Taiwan, Hong Kong and Macau which are not visited by the inspection teams). Treated cities are actively experiencing an inspection, while control cities are not. Every city appears once in the treated group and four times in the control group.

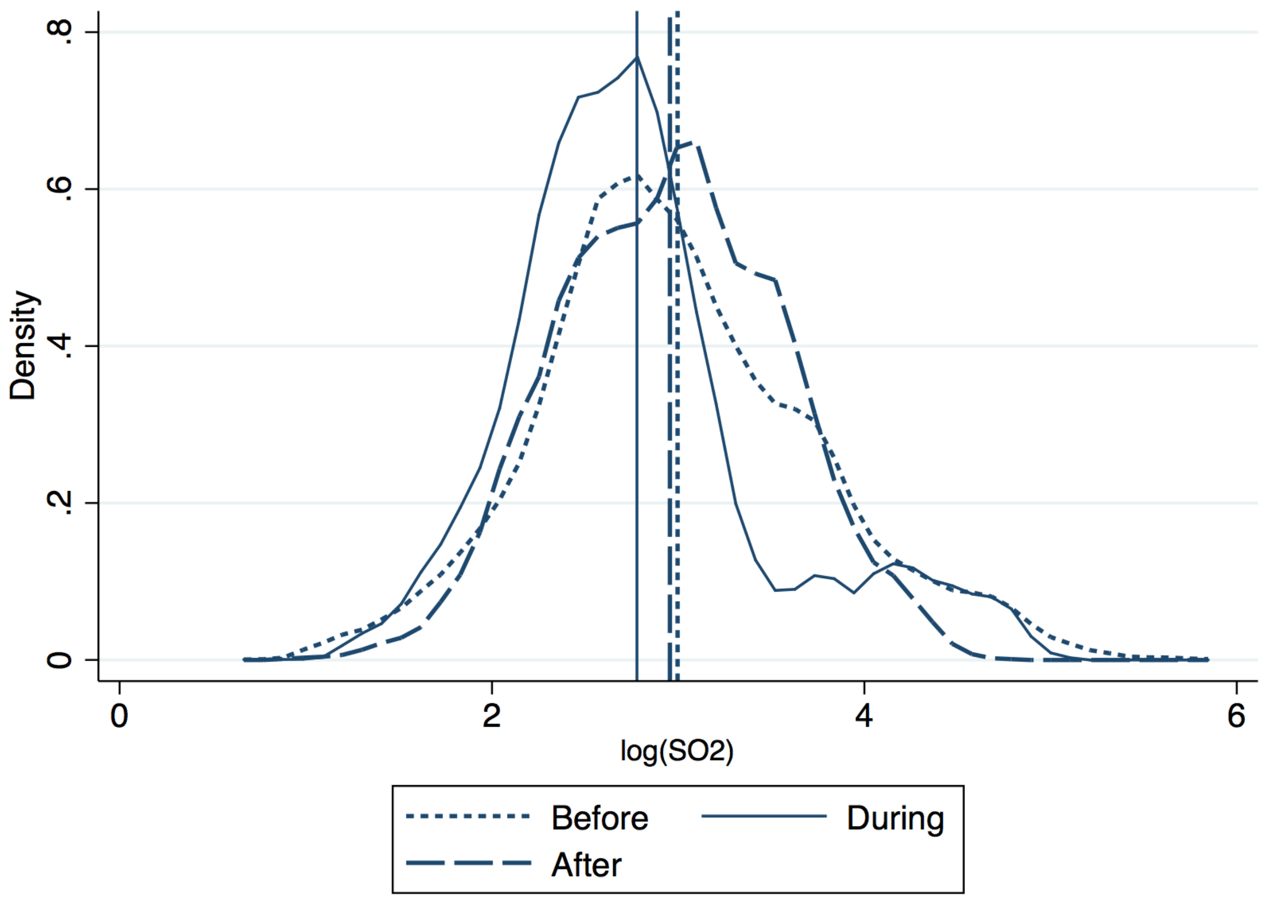



Figure 3. Distribution of $SO_2$ of average power plant emissions at plants in treated cities in the six-province entropy balanced sample before, during, and after (12 weeks) of an inspection. The vertical line represents the mean of the corresponding distribution.

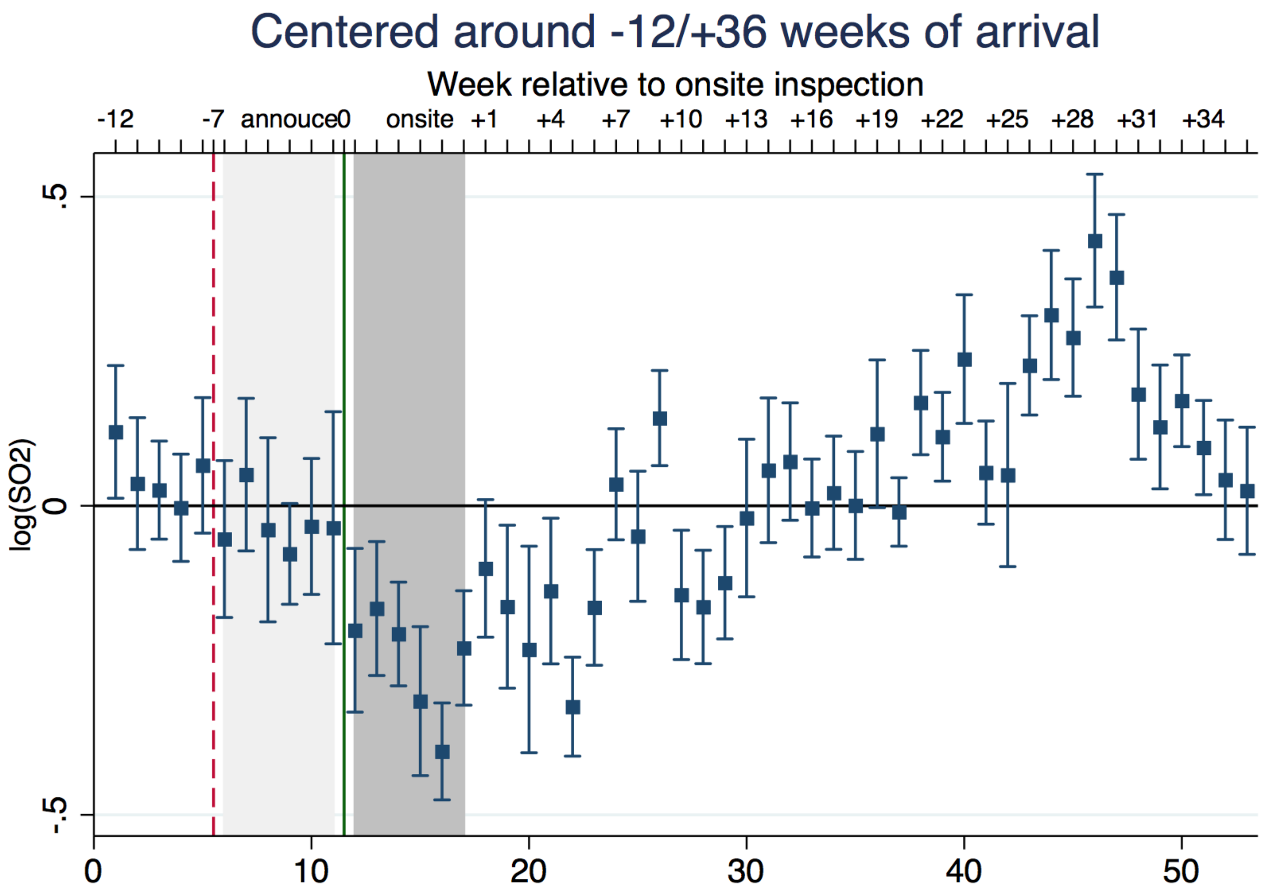



Figure 4. Event study showing percent change in $SO_2$ for each week relative to a reference week, which is defined as the week before a crackdown in announced (denoted by week -7). The graph is centered on the Announce and On-site periods of the inspections, with a 36-week post-inspection horizon. Coefficients are at weekly level in the post period.

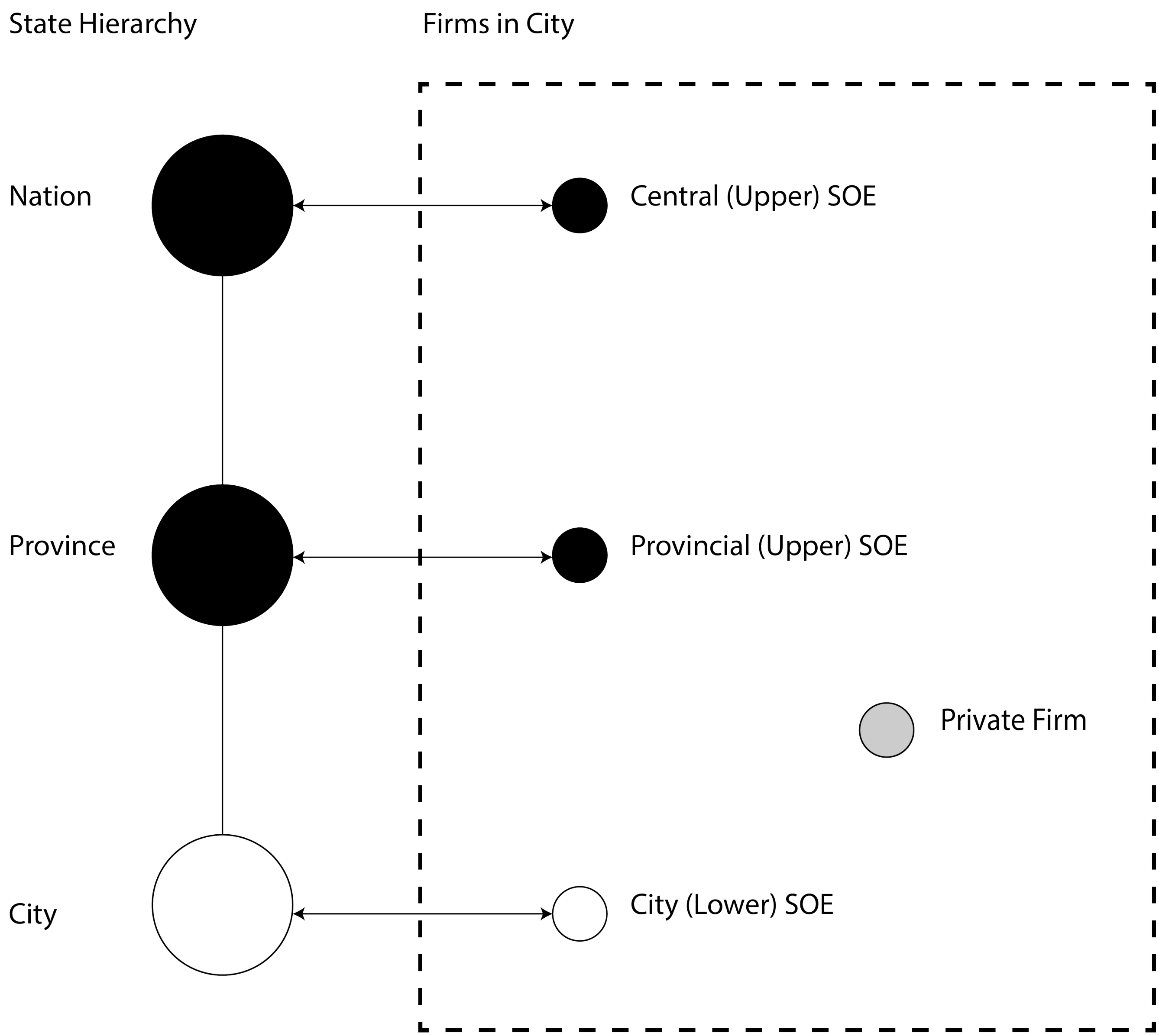



Figure 5. Schematic of China's governing hierarchy and linkages to industrial firms. SOE - state-owned enterprise

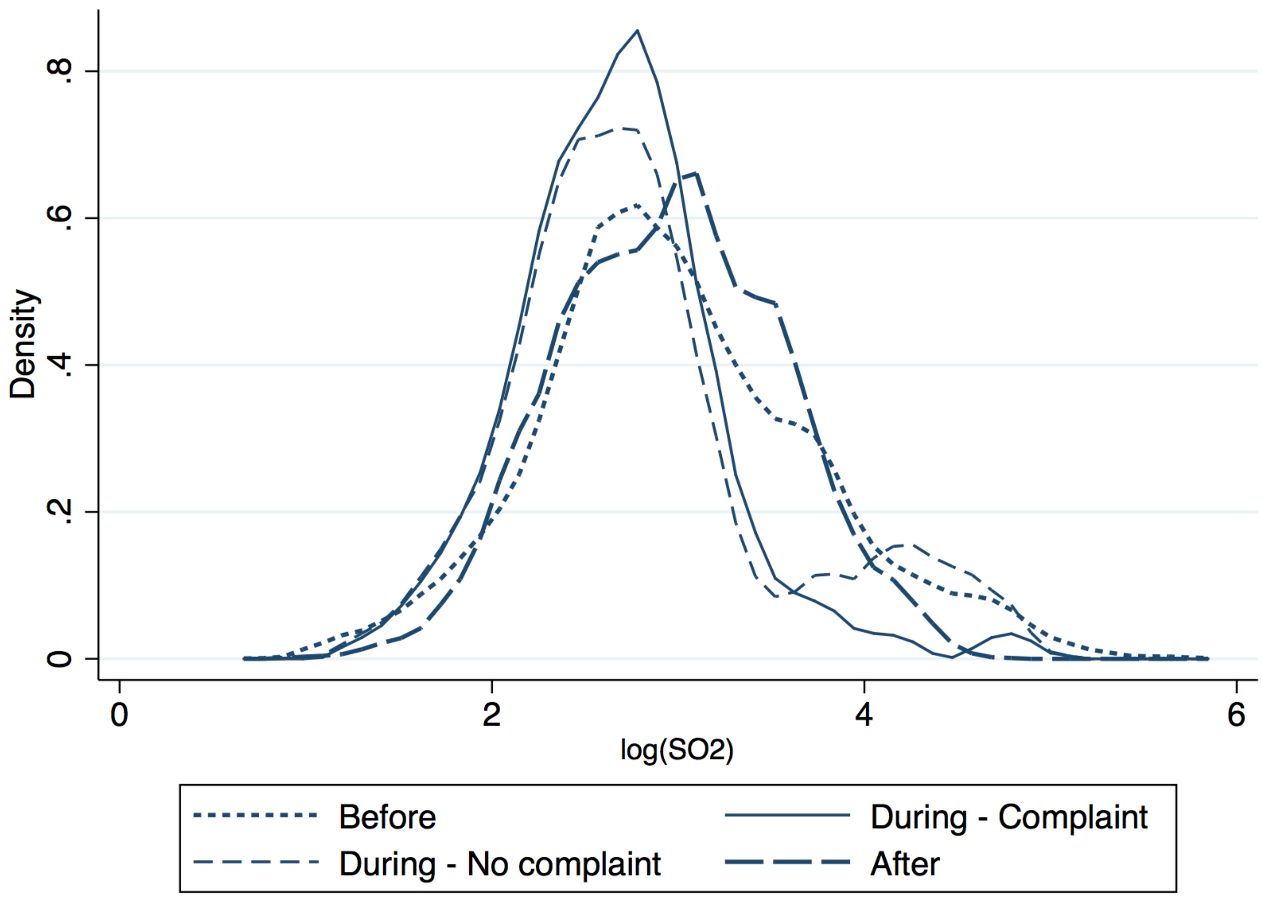



Figure 6. Distribution of power plant $SO_2$ emissions concentration near plants in treated cities in the six-province entropy balanced sample before, during, and after (12 weeks) inspections. Distributions of measurements during inspections are differentiated by complaint status (complaints precede measurements used to generate the inspection $SO_2$ distribution, which are taken during the final week of the inspection period).

Table 1. Summary statistics for the five inspection rounds.

| Summary | Trial Round | Round 1 | Round 2 | Round 3 | Round 4 |
|---|---|---|---|---|---|
| Number of provinces | 1 | 8 | 7 | 7 | 8 |
| Start date | 2015/12/31 | 2016/07/12 | 2016/11/24 | 2017/04/24 | 2017/08/07 |
| End date | 2016/02/14 | 2016/08/19 | 2016/12/30 | 2017/05/28 | 2017/09/15 |
| Avg. GDP (billion) | 3207 | 2577 | 3024 | 2139 | 2255 |
| Avg. population (million) | 63 | 41 | 37 | 36 | 32 |
| Avg. per-capita GDP | 51108 | 60725 | 85410 | 67145 | 60949 |
| Pre-Inspec $SO_2$ Concentr | 42 | 26 | 17 | 29 | 18 |
| Complaints | 2856 | 1637 | 2233 | 4494 | 5005 |
| Firms rectified | NA | NA | NA | 3471 | 4654 |
| Firms shutdown | 200 | NA | NA | NA | NA |
| Cases filed | 125 | NA | 901 | 1241 | 1351 |
| Fines (million) | NA | NA | NA | 5238 | 6755 |
| Persons detained | 123 | 39 | 38 | 58 | 53 |
| Persons interviewed | 65 | 272 | 667 | 951 | 607 |
| Officials accountable | 366 | 428 | 446 | 666 | 809 |

Notes: Trial Round, the pilot program, was launched in Hebei province. Round 1 includes 8 provincial-level regions: Inner Mongolia, Ningxia Hui, and Guangxi autonomous regions, as well as Heilongjiang, Jiangsu, Jiangxi, Henan, and Yunnan provinces. Round 2 include 7 provincial-level regions: Beijing, Shanghai, and Chongqing municipalities, as well as Hubei, Guangdong, Shaanxi, and Gansu provinces. Round 3 include 7 provincial-level regions: Tianjin municipality, as well as Shanxi, Liaoning, Anhui, Fujian, Hunan, and Guizhou provinces. Round 4 include 8 provincial-level regions: Tibet, and Xinjiang Uygur autonomous regions, as well as Qinghai, Sichuan, Hainan, Shandong, Zhejiang, and Jilin provinces. "NA" means that information is not available.

Table 2. Event study coefficients during baseline weeks.

| | **Original** | | **Entropy-Balanced** | |
|---|---|---|---|---|
| | (1) log($SO_2$) | (2) log($SO_2$) | (3) log($SO_2$) | (4) log($SO_2$) |
| Baseline (-12 wks) | 0.190*** | 0.224*** | 0.105* | 0.120** |
| | (0.030) | (0.029) | (0.055) | (0.053) |
| Baseline (-11 wks) | 0.091** | 0.143*** | 0.016 | 0.036 |
| | (0.039) | (0.033) | (0.052) | (0.053) |
| Baseline (-10 wks) | 0.078** | 0.094*** | 0.020 | 0.025 |
| | (0.034) | (0.035) | (0.039) | (0.039) |
| Baseline (-9 wks) | 0.051 | 0.067* | -0.008 | -0.003 |
| | (0.040) | (0.036) | (0.045) | (0.043) |
| Baseline (-8 wks) | 0.104** | 0.128** | 0.053 | 0.065 |
| | (0.050) | (0.048) | (0.054) | (0.055) |
| Elsewhere | | 0.102*** | | 0.039 |
| | | (0.017) | | (0.028) |
| Observations | 85,213 | 85,213 | 71,572 | 71,572 |
| R-squared | 0.642 | 0.644 | 0.638 | 0.639 |
| Number of plants | 973 | 973 | 973 | 973 |
| Plant FE | Yes | Yes | Yes | Yes |
| Year FE | Yes | Yes | Yes | Yes |
| Week FE | Yes | Yes | Yes | Yes |

Notes: Uses the original and entropy balanced full power plant sample. Event study showing percent change in $SO_2$ for each week relative to a reference week, which is defined as the week before a crackdown in announced (Week -7). Individual week coefficients for “Announce”, “On-site” and “Post” periods are suppressed. All specifications control for plant, year, and week fixed effects, which would absorb the effect of time-invariant unobservable characteristics, plus annual policy or operational changes and seasonal fluctuations in electricity demand. Robust standard errors are given in parentheses. Standard errors are clustered at the city level.

Table 3. Average effects of the announcement, on-site, and post-inspection periods in the entropy-balanced and original samples.

| | **Short-term** | | **Medium-term** | | **Long-term** | | | |
|---|---|---|---|---|---|---|---|---|
| | EB | Original | EB | Original | EB | Original | EB | Original |
| | (1) $\log(SO_2)$ | (2) $\log(SO_2)$ | (3) $\log(SO_2)$ | (4) $\log(SO_2)$ | (5) $\log(SO_2)$ | (6) $\log(SO_2)$ | (7) $\log(SO_2)$ | (8) $\log(SO_2)$ |
| Announce | -0.058 | -0.044 | -0.044 | -0.032 | -0.064 | -0.030 | -0.060 | -0.028 |
| | (0.043) | (0.038) | (0.041) | (0.037) | (0.039) | (0.036) | (0.039) | (0.036) |
| On-site | -0.273*** | -0.272*** | -0.254*** | -0.286*** | -0.251*** | -0.279*** | -0.255*** | -0.280*** |
| | (0.046) | (0.044) | (0.039) | (0.038) | (0.038) | (0.035) | (0.038) | (0.035) |
| Post | -0.178*** | -0.166*** | -0.117*** | -0.103*** | -0.061*** | -0.046*** | -0.078*** | -0.067*** |
| | (0.038) | (0.029) | (0.025) | (0.017) | (0.019) | (0.013) | (0.020) | (0.013) |
| Elsewhere | 0.024 | 0.025* | 0.074*** | 0.052*** | 0.058*** | 0.050*** | 0.057*** | 0.049*** |
| | (0.017) | (0.013) | (0.020) | (0.015) | (0.018) | (0.013) | (0.019) | (0.014) |
| Post 12-23 wks | | | | | | | -0.019 | -0.011 |
| | | | | | | | (0.017) | (0.018) |
| Post 24-36 wks | | | | | | | 0.091** | 0.104*** |
| | | | | | | | (0.038) | (0.032) |
| Observations | 103,502 | 129,697 | 145,548 | 182,960 | 186,731 | 235,682 | 186,731 | 235,682 |
| R-squared | 0.711 | 0.744 | 0.708 | 0.738 | 0.700 | 0.727 | 0.701 | 0.727 |
| # of plants | 973 | 973 | 973 | 973 | 973 | 973 | 973 | 973 |
| Plant FE | Yes | Yes | Yes | Yes | Yes | Yes | Yes | Yes |
| Year FE | Yes | Yes | Yes | Yes | Yes | Yes | Yes | Yes |
| Week FE | Yes | Yes | Yes | Yes | Yes | Yes | Yes | Yes |

Notes: EB refers to estimates using the entropy-balanced sample. Baseline weeks (prior to the announcement period) are the omitted reference group. All specifications include plant, year, and week fixed effects. "Announce" refers to the announcement period, the earliest window during which a city would have learned inspectors were coming. "On-site" refers to the inspection period. "Post" refers to the period after the inspection ends. "Elsewhere" controls for an inspection underway in a non-focal province. All specifications control for plant, year, and week fixed effects, which would absorb the effect of time-invariant unobservable characteristics, plus annual policy or operational changes and seasonal fluctuations in electricity demand. Robust standard errors are given in parentheses. Standard errors are clustered at the city level.

Table 4. Summary statistics for power plants in the six-province sample.

| | | Total | Henan | Shandong | Hebei | Guangdong | Hubei | Shanxi |
|---|---|---|---|---|---|---|---|---|
| Ownership status | Central SOE | 166 | 31 | 52 | 29 | 11 | 22 | 21 |
| | Provincial SOE | 168 | 29 | 24 | 39 | 19 | 3 | 54 |
| | Local SOE | 157 | 14 | 89 | 17 | 24 | 10 | 3 |
| | Private | 465 | 48 | 236 | 36 | 76 | 35 | 34 |
| $SO_2$ Scrubber | With scrubbers | 772 | 105 | 348 | 107 | 85 | 32 | 95 |
| | No scrubbers | 201 | 17 | 65 | 14 | 50 | 38 | 17 |
| Complaint status | Complained | 266 | 32 | 113 | 13 | 44 | 22 | 42 |
| | Non-complained | 707 | 90 | 300 | 108 | 91 | 48 | 70 |
| Capacity | Mean | 339.63 | 506.82 | 186.44 | 354.57 | 513.90 | 336.41 | 498.24 |
| | Median | 50.00 | 270.00 | 30.00 | 48.00 | 150.00 | 26.00 | 270.00 |
| | Standard Deviation | 590.07 | 662.70 | 419.59 | 548.60 | 832.25 | 643.43 | 563.27 |
| Pre-inspection $SO_2$ (Treated cities) | Mean | 29.97 | 29.76 | 21.92 | 38.03 | 12.84 | 15.97 | 100.40 |
| | Median | 21.69 | 28.53 | 19.23 | 38.53 | 12.71 | 13.68 | 88.68 |
| | Standard Deviation | 28.84 | 9.61 | 11.00 | 13.72 | 4.75 | 8.64 | 49.35 |
| Announce $SO_2$ (Treated cities) | Mean | 24.46 | 18.84 | 14.68 | 72.98 | 13.21 | 12.76 | 40.62 |
| | Median | 15.88 | 18.78 | 13.21 | 69.12 | 12.73 | 11.60 | 36.73 |
| | Standard Deviation | 24.00 | 8.20 | 7.73 | 28.63 | 6.17 | 6.48 | 20.35 |
| On-site $SO_2$ (Treated cities) | Mean | 21.28 | 12.57 | 13.38 | 70.75 | 14.54 | 17.22 | 22.27 |
| | Median | 14.46 | 10.15 | 12.53 | 66.11 | 14.15 | 16.41 | 19.77 |
| | Standard Deviation | 21.68 | 8.21 | 5.82 | 28.24 | 5.24 | 7.51 | 10.67 |
| Post $SO_2$ (Treated cities) | Mean | 22.86 | 24.39 | 21.49 | 45.17 | 11.16 | 16.66 | 20.87 |
| | Median | 19.52 | 23.70 | 19.99 | 44.31 | 10.44 | 15.01 | 19.30 |
| | Standard Deviation | 14.19 | 9.98 | 10.15 | 17.97 | 4.52 | 8.64 | 9.26 |
| Pre-inspection $SO_2$ (Control cities) | Mean | 30.22 | 29.64 | 37.54 | 33.48 | 12.33 | 15.07 | 36.49 |
| | Median | 26.23 | 27.30 | 33.42 | 30.48 | 10.80 | 13.19 | 29.46 |
| | Standard Deviation | 19.70 | 13.96 | 19.45 | 19.32 | 6.93 | 8.67 | 23.56 |
| Announce $SO_2$ (Control cities) | Mean | 30.94 | 30.79 | 36.71 | 27.80 | 11.63 | 14.32 | 57.73 |
| | Median | 22.46 | 25.07 | 27.27 | 25.97 | 10.40 | 12.01 | 33.95 |
| | Standard Deviation | 28.89 | 22.50 | 26.72 | 15.21 | 5.49 | 9.16 | 56.21 |
| On-site $SO_2$ (Control cities) | Mean | 34.44 | 35.05 | 38.50 | 32.55 | 11.16 | 13.76 | 74.75 |
| | Median | 23.67 | 30.25 | 31.94 | 26.73 | 10.26 | 11.17 | 42.59 |
| | Standard Deviation | 34.29 | 21.95 | 26.20 | 23.19 | 4.76 | 8.42 | 74.46 |
| Post $SO_2$ (Control cities) | Mean | 29.55 | 28.95 | 32.36 | 30.70 | 11.38 | 13.96 | 61.60 |
| | Median | 22.58 | 24.48 | 28.53 | 26.29 | 10.61 | 11.87 | 46.56 |
| | Standard Deviation | 25.19 | 18.10 | 19.33 | 21.29 | 4.93 | 8.49 | 48.97 |

Notes: Summary statistics are calculated from the raw data, without accounting for geographical or seasonal trends. Unit of measure for $SO_2$ is $\mu g/m^3$. Mean refers to simple means of the sample observations for each round. Each province is sampled at random from within each round. Median and standard deviations within rounds are also shown.

Table 5. Effects on $NO_X$ at plants during the announcement, on-site, and post-inspection periods.

| | Short-term | Medium-term | Long-term | |
|---|---|---|---|---|
| | (1) log($NO_X$) | (2) log($NO_X$) | (3) log($NO_X$) | (4) log($NO_X$) |
| Announce | -0.045* | -0.037 | -0.036 | -0.039 |
| | (0.023) | (0.023) | (0.025) | (0.025) |
| On-site | -0.071** | -0.033 | -0.048* | -0.043 |
| | (0.028) | (0.029) | (0.028) | (0.028) |
| Post | 0.053*** | 0.060*** | 0.034** | 0.041*** |
| | (0.017) | (0.018) | (0.013) | (0.013) |
| Elsewhere | -0.001 | 0.040** | 0.025 | 0.027* |
| | (0.018) | (0.017) | (0.015) | (0.015) |
| Post 12-23 wks | | | | 0.031** |
| | | | | (0.015) |
| Post 24-36 wks | | | | -0.060*** |
| | | | | (0.018) |
| Observations | 80,372 | 113,009 | 144,958 | 144,958 |
| R-squared | 0.723 | 0.709 | 0.708 | 0.709 |
| Number of plants | 769 | 769 | 769 | 769 |
| Plant FE | Yes | Yes | Yes | Yes |
| Year FE | Yes | Yes | Yes | Yes |
| Week FE | Yes | Yes | Yes | Yes |

Notes: Uses the entropy-balanced power plant sample. $NO_X$ is a proxy for plant power output. All plants included in our subsample do not have $NO_X$ scrubbers installed, to ensure that any changes in $NO_X$ levels are due to fluctuations in plant output. Standard errors are clustered at the city level. See Appendix Table A.8 for results using the original (not entropy-balanced) sample.

Table 6. Effect of inspections interacted with a firm's Upper SOE (USOE) status in the on-site and post-inspection periods.

| | (1) log($SO_2$) | (2) log($SO_2$) | (3) log($SO_2$) | (4) log($SO_2$) | (5) log($SO_2$) |
|---|---|---|---|---|---|
| Announce | -0.056* | -0.057* | -0.056* | -0.056* | -0.056* |
| | (0.031) | (0.032) | (0.032) | (0.031) | (0.032) |
| On-site | -0.252*** | -0.254*** | -0.252*** | -0.252*** | -0.253*** |
| | (0.029) | (0.029) | (0.029) | (0.029) | (0.029) |
| Post 0-11 wks | -0.178*** | -0.172*** | -0.202*** | -0.178*** | -0.178*** |
| | (0.028) | (0.028) | (0.034) | (0.028) | (0.028) |
| Post 12-23 wks | -0.092*** | -0.086*** | -0.092*** | -0.086*** | -0.092*** |
| | (0.022) | (0.020) | (0.022) | (0.023) | (0.022) |
| Post 24-36 wks | 0.025 | 0.030 | 0.025 | 0.025 | 0.037 |
| | (0.026) | (0.024) | (0.026) | (0.026) | (0.029) |
| Elsewhere | 0.047*** | 0.047*** | 0.047*** | 0.047*** | 0.047*** |
| | (0.014) | (0.014) | (0.014) | (0.014) | (0.014) |
| On-site × Upper SOE | | -0.020 | | | |
| | | (0.019) | | | |
| Post 0-11 wks × Upper SOE | | | 0.065* | | |
| | | | (0.036) | | |
| Post 12-23 wks × Upper SOE | | | | -0.016 | |
| | | | | (0.023) | |
| Post 24-36 wks × Upper SOE | | | | | -0.035 |
| | | | | | (0.031) |
| Observations | 186,731 | 186,731 | 186,731 | 186,731 | 186,731 |
| R-squared | 0.703 | 0.703 | 0.703 | 0.703 | 0.703 |
| Number of plants | 973 | 973 | 973 | 973 | 973 |
| Plant FE | Yes | Yes | Yes | Yes | Yes |
| Year FE | Yes | Yes | Yes | Yes | Yes |
| Week FE | Yes | Yes | Yes | Yes | Yes |

Notes: Uses the entropy balanced power plant sample. USOE - Upper SOE. Coefficient estimates are average effects within multi-week periods, relative to the inspection. Baseline weeks (prior to the announcement period) are the omitted reference group. "Announce" refers to the announcement period, the earliest window during which a city would have learned inspectors were coming. "On-site" refers to the inspection period. "Post" refers to the period after the inspection ends. "Elsewhere" controls for an inspection underway in a non-focal province. Regression is the full interaction of Upper SOE status with covariates. The interaction between ownership/oversight status and Post periods of varying length captures variation in the post-inspection response by ownership/oversight level. All specifications include plant, year, and week fixed effects. All specifications control for plant, year, and week fixed effects, which would absorb the effect of time-invariant unobservable characteristics, plus annual policy or operational changes and seasonal fluctuations in electricity demand. Robust standard errors are given in parentheses. Standard errors are clustered at the city level. See Appendix Table A.9 for results using the original (not entropy-balanced) sample.

Table 7. Direct effect of campaign with interactions on scrubber technology in different post periods by plant oversight.

| | All<br>(1) log($SO_2$) | Upper SOE<br>(2) log($SO_2$) | Lower SOE<br>(3) log($SO_2$) | Private<br>(4) log($SO_2$) |
|---|---|---|---|---|
| Announce | -0.055 | -0.056 | -0.042 | -0.062 |
| | (0.039) | (0.040) | (0.072) | (0.040) |
| On-site | -0.253*** | -0.245*** | -0.224*** | -0.263*** |
| | (0.037) | (0.052) | (0.054) | (0.031) |
| Post 0-11 wks | -0.338*** | -0.399*** | -0.226*** | -0.325*** |
| | (0.051) | (0.076) | (0.065) | (0.054) |
| Post 12-23 wks | -0.093*** | -0.101*** | -0.070** | -0.083*** |
| | (0.025) | (0.034) | (0.030) | (0.025) |
| Post 24-36 wks | 0.026 | 0.012 | 0.025 | 0.036 |
| | (0.033) | (0.035) | (0.034) | (0.045) |
| Elsewhere | 0.046*** | 0.058** | 0.057*** | 0.038* |
| | (0.016) | (0.024) | (0.020) | (0.020) |
| Post 0-11 wks × $SO_2$ Scrubber | 0.196*** | 0.268*** | 0.067 | 0.175*** |
| | (0.046) | (0.080) | (0.074) | (0.049) |
| Observations | 186,731 | 65,600 | 33,527 | 84,251 |
| R-squared | 0.704 | 0.706 | 0.694 | 0.694 |
| Number of plants | 973 | 334 | 157 | 465 |
| Plant FE | Yes | Yes | Yes | Yes |
| Year FE | Yes | Yes | Yes | Yes |
| Week FE | Yes | Yes | Yes | Yes |

Notes: Uses the entropy balanced power plant sample. USOE - upper SOE, LSOE - lower SOE. Column (2) includes only upper SOE firms (state-owned enterprises with national-level or provincial-level oversight). Column (3) includes only firms that are lower SOE (state-owned enterprises with city-level or county-level oversight). Column (4) uses only firms that are private enterprises. Coefficient estimates are average effects over multi-week periods. Baseline weeks (prior to the announcement period) are the omitted reference group. "Announce" refers to the announcement period, the earliest window during which a city would have learned inspectors were coming. "On-site" refers to the inspection period. "Post" refers to the period after the inspection ends. "Elsewhere" controls for an inspection underway in a non-focal province. All specifications control for plant, year, and week fixed effects, to absorb the effect of time-invariant unobservable characteristics, plus annual policy or operational changes and seasonal fluctuations in electricity demand. Robust standard errors are given in parentheses. Standard errors are clustered at the city level. See Appendix Table A.10 for results using the original (not entropy-balanced) sample.

Table 8. Effect of inspections with interactions on scrubber technology in different post period by plant capacity (MW).

| | All | Cap $\leq$ 100 MW | 100 MW $<$ Cap $\leq$1000 MW | Cap $>$1000 MW |
|---|---|---|---|---|
| | (1) log($SO_2$) | (2) log($SO_2$) | (3) log($SO_2$) | (4) log($SO_2$) |
| Announce | -0.055 | -0.036 | -0.089** | -0.026 |
| | (0.039) | (0.049) | (0.037) | (0.041) |
| On-site | -0.253*** | -0.234*** | -0.301*** | -0.207*** |
| | (0.037) | (0.044) | (0.049) | (0.048) |
| Post 0-11 wks | -0.338*** | -0.310*** | -0.446*** | -0.516*** |
| | (0.051) | (0.060) | (0.080) | (0.188) |
| Post 12-23 wks | -0.093*** | -0.100*** | -0.093*** | -0.066 |
| | (0.025) | (0.024) | (0.029) | (0.041) |
| Post 24-36 wks | 0.026 | -0.004 | 0.075* | 0.061* |
| | (0.033) | (0.038) | (0.043) | (0.031) |
| Elsewhere | 0.046*** | 0.034** | 0.065*** | 0.056* |
| | (0.016) | (0.017) | (0.022) | (0.031) |
| Post 0-11 wks $\times$ $SO_2$ Scrubber | 0.196*** | 0.197*** | 0.263*** | 0.377* |
| | (0.046) | (0.050) | (0.083) | (0.190) |
| Observations | 186,731 | 107,115 | 54,718 | 23,835 |
| R-squared | 0.704 | 0.712 | 0.697 | 0.707 |
| Number of plants | 973 | 571 | 282 | 116 |
| Plant FE | Yes | Yes | Yes | Yes |
| Year FE | Yes | Yes | Yes | Yes |
| Week FE | Yes | Yes | Yes | Yes |

Notes: Uses the entropy balanced power plant sample. Column (2) includes only firms with electricity production capacity $\leq$ 100 MW. Column (3) includes only firms with electricity production capacity $>$ 100 MW and $\leq$ 1000 MW. Column (4) includes only firms with electricity production capacity $>$ 1000 MW. Coefficient estimates are average effects over multi-week periods. Baseline weeks (prior to the announcement period) are the omitted reference group. "Announce" refers to the announcement period, the earliest window during which a city would have learned inspectors were coming. "On-site" refers to the inspection period. "Post" refers to the period after the inspection ends. "Elsewhere" controls for an inspection underway in a non-focal province. All specifications control for plant, year, and week fixed effects, to absorb the effect of time-invariant unobservable characteristics, plus annual policy or operational changes and seasonal fluctuations in electricity demand. Robust standard errors are given in parentheses. Standard errors are clustered at the city level. See Appendix Table A.11 for results using the original (not entropy-balanced) sample.

Table 9. Outcomes of citizen complaints by ownership and oversight-level

| | (1) Complaint | (2) Rectified | (3) Shutdown | (4) Officials accountable |
|---|---|---|---|---|
| Central SOE | 47 (28%) | 23 (49%) | 0 (0%) | 5 (11%) |
| Provincial SOE | 47 (28%) | 31 (66%) | 1 (2%) | 11 (23%) |
| Local SOE | 41 (26%) | 20 (49%) | 0 (0%) | 4 (10%) |
| Private | 128 (28%) | 76 (59%) | 4 (3%) | 20 (16%) |

Notes: Uses the full power plant sample. Numbers and (in parentheses) percentages within each group plants receiving complaints are shown in column (1). Numbers/percentages of plants receiving complaints that were subsequently ordered to rectify pollution or shutdown, or for which officials were held accountable for plant violations, are shown in columns (2)-(4).

Table 10. Logit regression relating firm/city characteristics to complaint status.

| | (1) | (2) | (3) | (4) | (5) | (6) | (7) | (8) | (9) | (10) |
|---|---|---|---|---|---|---|---|---|---|---|
| log(per_capita) | 0.309** | | | | | | | | | 0.366** |
| | (0.145) | | | | | | | | | (0.174) |
| log(pop_dens) | | -0.362*** | | | | | | | | -0.373** |
| | | (0.136) | | | | | | | | (0.164) |
| log(dist_to_center) | | | -0.0300 | | | | | | | -0.0345 |
| | | | (0.0708) | | | | | | | (0.0833) |
| revenue_share_city | | | | -0.156 | | | | | | 0.0477 |
| | | | | (1.176) | | | | | | (1.215) |
| log(company_age) | | | | | -13.72 | | | | | -7.015 |
| | | | | | (8.722) | | | | | (9.664) |
| Upper SOE | | | | | | 0.0195 | | | | -0.0629 |
| | | | | | | (0.145) | | | | (0.190) |
| Lower SOE | | | | | | | -0.0302 | | | -0.0759 |
| | | | | | | | (0.188) | | | (0.227) |
| Announce $SO_2$ | | | | | | | | 0.00115 | | 0.00162 |
| | | | | | | | | (0.00195) | | (0.00414) |
| Baseline $SO_2$ | | | | | | | | | 0.00204 | -0.00167 |
| | | | | | | | | | (0.00373) | (0.00764) |
| Observations | 973 | 965 | 973 | 810 | 814 | 973 | 973 | 871 | 864 | 713 |
| Pseudo R2 | 0.00373 | 0.00581 | 0.000147 | 1.71e-05 | 0.00236 | 1.50e-05 | 2.13e-05 | 0.000322 | 0.000278 | 0.0128 |

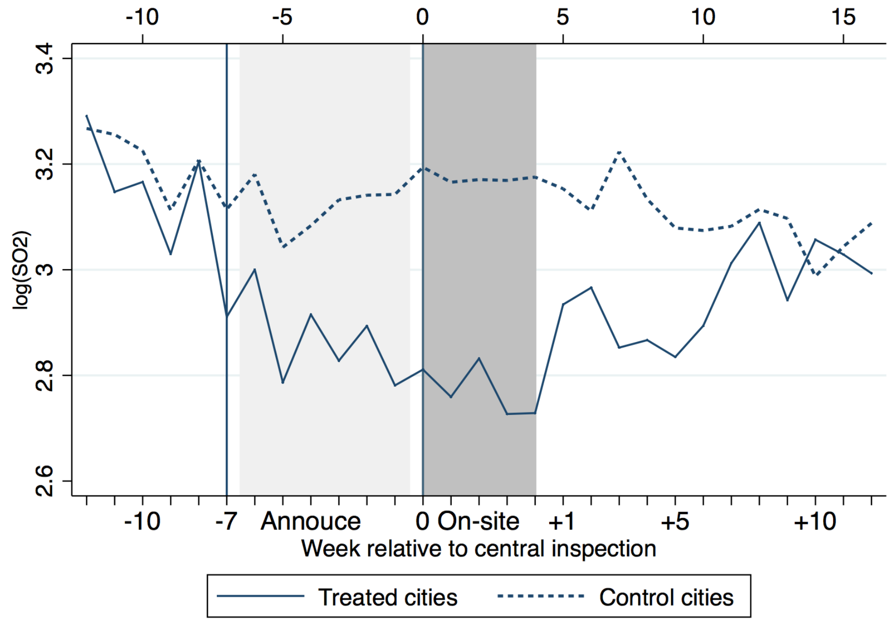
Notes: Uses the six-province power plant sample. Dependent variable is equal to 1 if a firm receives a complaint, and zero otherwise. Covariates include (in order) the log of per-capita income, log of population density, log of distance to city center, log of company age, a dummy for SOE type (equal to one if upper or lower, and otherwise zero for the two variables, respectively). USOE - Upper SOE, LSOE - Lower SOE. Announce and Baseline $SO_2$ are measured in $\mu g/m^3$. The dependent variable is equal to one if a firm receives a complaint and zero otherwise. Standard errors are in parentheses.

Table 11. Effect of inspections with interactions on plants receiving a complaint.

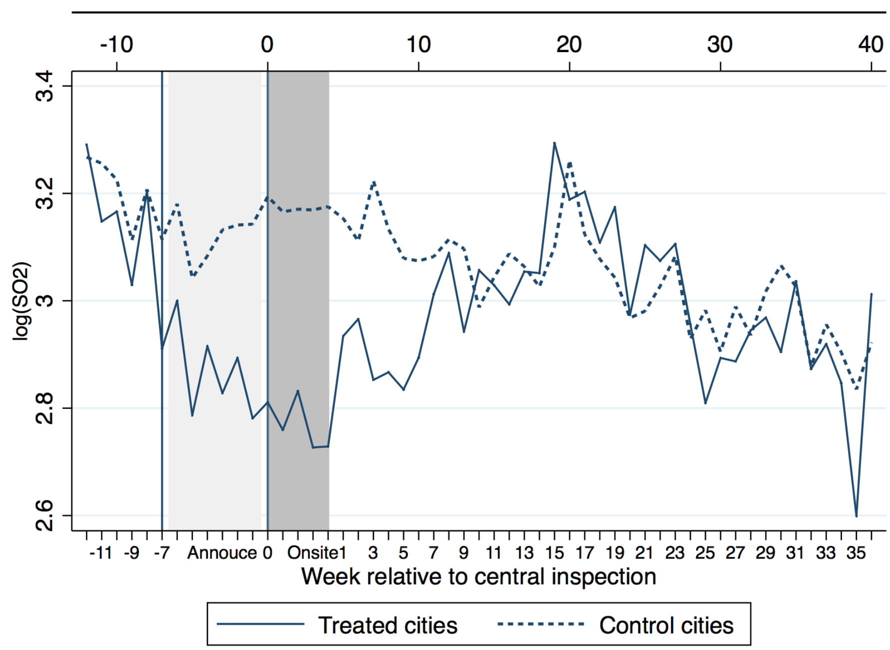
| | (1) log($SO_2$) | (2) log($SO_2$) | (3) log($SO_2$) | (4) log($SO_2$) |
|---|---|---|---|---|
| Announce | -0.041 | -0.058 | -0.058 | -0.058 |
| | (0.046) | (0.042) | (0.043) | (0.043) |
| On-site | -0.273*** | -0.252*** | -0.273*** | -0.273*** |
| | (0.046) | (0.051) | (0.046) | (0.046) |
| Post | -0.178*** | -0.178*** | -0.174*** | -0.174*** |
| | (0.038) | (0.038) | (0.039) | (0.039) |
| Elsewhere | 0.024 | 0.023 | 0.024 | 0.024 |
| | (0.017) | (0.017) | (0.017) | (0.017) |
| Announce × Complaint | -0.060** | | | |
| | (0.025) | | | |
| On-site × Complaint | | -0.075** | | |
| | | (0.031) | | |
| Post × Complaint | | | -0.015 | -0.045 |
| | | | (0.033) | (0.037) |
| Post × Complaint x Upper SOE | | | | 0.082 |
| | | | | (0.059) |
| Observations | 103,502 | 103,502 | 103,502 | 103,502 |
| R-squared | 0.711 | 0.711 | 0.711 | 0.711 |
| Number of plants | 973 | 973 | 973 | 973 |
| Plant FE | Yes | Yes | Yes | Yes |
| Year FE | Yes | Yes | Yes | Yes |
| Week FE | Yes | Yes | Yes | Yes |

Notes: Uses the entropy-balanced power plant sample. USOE - Upper SOE. Sample used in this table only spans to "Post 0-11 wks", that is until 12 weeks after the inspection ends. Coefficient estimates are average effects within multi-week periods, relative to the inspection. Baseline weeks (prior to the announcement period) are the omitted reference group. "Announce" refers to the announcement period, the earliest window during which a city would have learned inspectors were coming. "On-site" refers to the inspection period. "Post" refers to the period after the inspection ends. "Elsewhere" controls for an inspection underway in a non-focal province. In columns (1)-(3), the periods defined by the inspection ("Announce," "On-site," and "Post") are interacted with complaint status (equal to one if a plant receives a complaint, and otherwise zero). In column (4), complaint status is further interacted with Upper SOE status. All specifications include plant, year, and week fixed effects. All specifications control for plant, year, and week fixed effects, which would absorb the effect of time-invariant unobservable characteristics, plus annual policy or operational changes and seasonal fluctuations in electricity demand. Robust standard errors are given in parentheses. Standard errors are clustered at the city level. See Appendix Table A.12 for results using the original (not entropy-balanced) sample.

# Appendix




(a) Short-term




(b) Long-term

Figure A.1: Comparison of log($SO_2$) concentrations at plants in treated and control cities around the inspection event window, using data for the six-province sample. The graph is centered on the timing of inspection in treated cities. Non-target cities serve as a control group in each respective round. Data covers all six provinces in our sample. Treated cities actively experience an inspection during the "on-site" period, while control cities do not. Every city appears once in the treated group and four times in the control group.

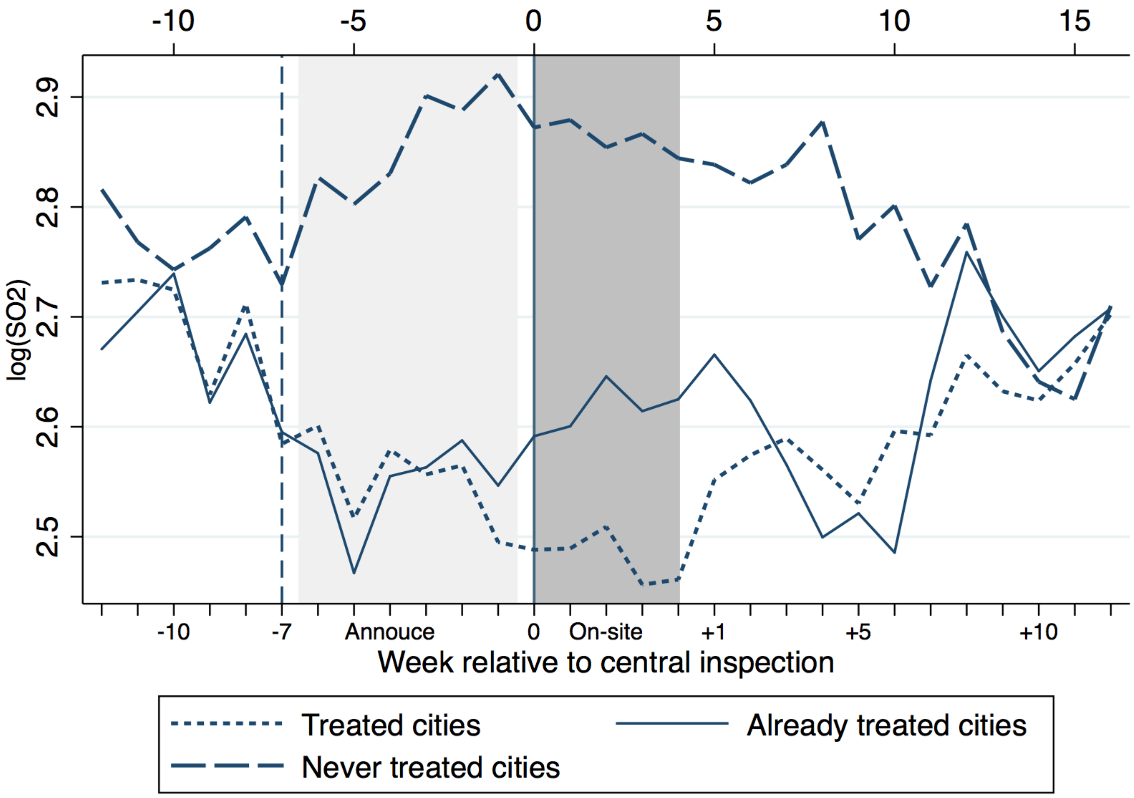
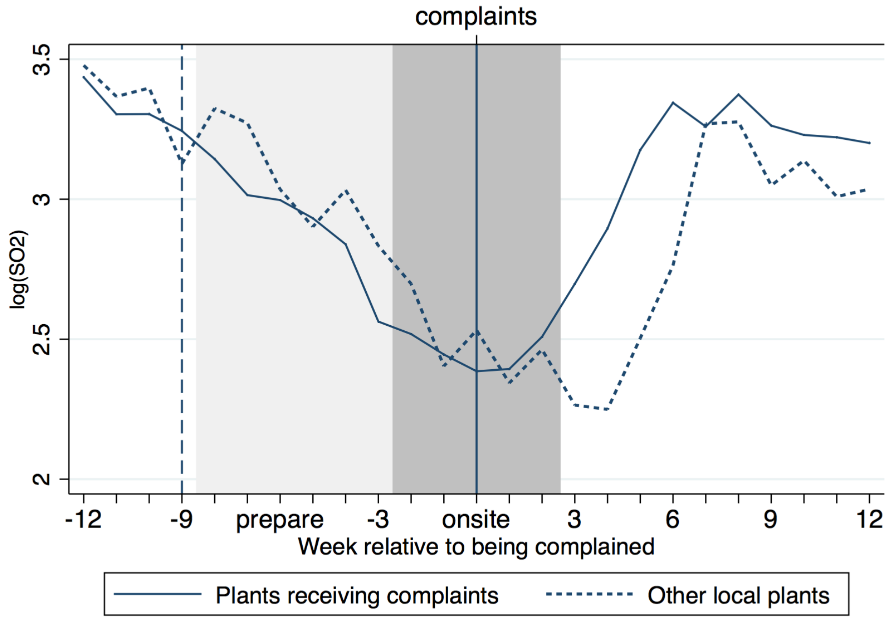
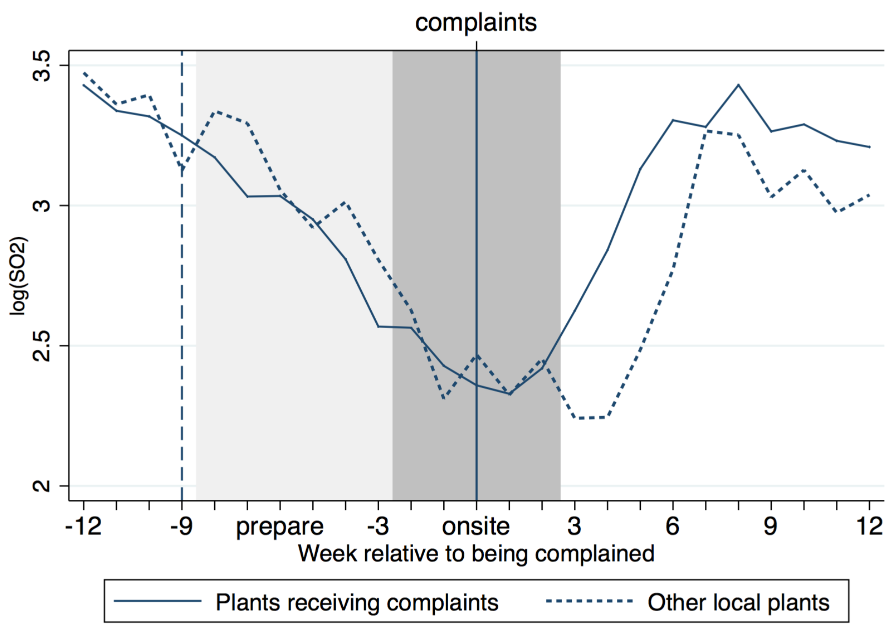



Figure A.2: Comparison of $\log(SO_2)$ concentration near plants in treated, already-treated control and never-treated control cities around the inspection event window. The graph is centered on the timing of inspection in treated cities. Data covers all 31 provincial-level administrative regions in mainland China (excluding Taiwan, Hong Kong and Macau which are not visited by the inspection teams). Treated cities are actively experiencing an inspection, already-treated cities are those that have previously had an inspection, and never-treated cities have not yet had an inspection.




(a) Monitor-level data




(b) CEMS data

Figure A.3: Comparison of log($SO_2$) concentrations at power plants that receive complaints (treated) compared to those that do not (control), using two different data sources for Henan province. Monitor-level data are ambient pollution measurements by the monitor installed nearest to a power plant, while continuous emissions monitoring system (CEMS) data are measured in the stack gases of an individual power plant. The graph is centered on the timing of receiving a complaint.

Table A.1: Difference-in-means and t-test statistics between plants in treated and control cities in the six-province original sample (before entropy balancing).

| | (1) Trial Round | (2) Round 1 | (3) Round 2 | (4) Round 3 | (5) Round 4 |
|---|---|---|---|---|---|
| log(per capita) | 0.194*** | 0.220*** | -0.101** | 0.333*** | -0.255*** |
| | (4.23) | (4.83) | (-2.71) | (7.15) | (-8.58) |
| log(pop density) | -0.352*** | 0.0863 | -0.0199 | 0.580*** | -0.113*** |
| | (-7.35) | (1.77) | (-0.50) | (12.37) | (-3.48) |
| log(distance to center) | 0.0815 | 0.192* | 0.233** | -0.170 | -0.210*** |
| | (0.86) | (2.05) | (3.06) | (-1.75) | (-3.36) |
| revenue share city | 0.00187 | 0.00226 | -0.00348 | -0.00889 | 0.00409 |
| | (0.28) | (0.32) | (-0.66) | (-1.20) | (0.90) |
| log(company age) | 0.00277** | -0.000336 | -0.00188** | -0.000289 | 0.000380 |
| | (3.19) | (-0.37) | (-2.76) | (-0.30) | (0.65) |
| Upper SOE | -0.250*** | -0.170*** | 0.0950* | -0.369*** | 0.277*** |
| | (-5.49) | (-3.72) | (2.55) | (-7.97) | (9.37) |
| Lower SOE | 0.0238 | 0.0533 | -0.00570 | 0.152*** | -0.0941*** |
| | (0.67) | (1.50) | (-0.20) | (4.15) | (-3.97) |
| announce $SO_2$ ($\mu g/m^3$) | -14.14*** | 0.877 | 55.61*** | -62.11*** | -14.58*** |
| | (-3.80) | (0.24) | (24.11) | (-15.75) | (-5.80) |
| baseline $SO_2$ ($\mu g/m^3$) | -1.073 | -0.599 | 24.96*** | -24.77*** | -9.611*** |
| | (-0.54) | (-0.31) | (18.88) | (-11.26) | (-7.29) |
| Observations | 973 | 973 | 973 | 973 | 973 |

Notes: t-statistics are shown in parentheses. *** p<0.01, ** p<0.05, * p<0.1

Table A.2: Relationship between city characteristics and ordering of inspections in the 31-province sample.

| | (1) Trial Round | (2) Round 2 | (3) Round 3 | (4) Round 4 |
|---|---|---|---|---|
| demeaned announce $SO_2$ ($\mu g/m^3$) | 0.0638 | 0.0148 | 0.0141 | -0.0267 |
| | (0.104) | (0.0538) | (0.0503) | (0.0500) |
| demeaned baseline $SO_2$ ($\mu g/m^3$) | -0.0708 | -0.0167 | -0.0160 | 0.0298 |
| | (0.118) | (0.0603) | (0.0563) | (0.0550) |
| log(pop_density) | 1.602*** | 0.274 | 0.263 | -0.433** |
| | (0.556) | (0.219) | (0.203) | (0.172) |
| log(per_capita) | -0.301 | -0.0868 | -0.0737 | 0.159 |
| | (0.547) | (0.269) | (0.251) | (0.238) |
| Observations | 333 | 333 | 333 | 333 |
| Pseudo R2 | 0.0297 | 0.0297 | 0.0297 | 0.0297 |

Notes: M-logit regressions to predicting the round in which a city is included. Observable characteristics of cities are included in combination as covariates. Round 1 is used as the base category. Covariates include the log of per-capita income, log of population density, Announce $SO_2$ corresponds to the average $SO_2$ concentration in a city 1 to 6 weeks prior. Baseline $SO_2$ corresponds to the average $SO_2$ concentration in a city 7 to 12 weeks prior. The dependent variable is the round in which the city is inspected. Standard errors are in parentheses. Includes only cities in six-province sample. *** $p<0.01$, ** $p<0.05$, * $p<0.1$

Table A.3: Within-rounds linear probability and logit model predicting treatment and control status of cities by round in the 31-province sample.

| | (1) Trial Round | (2) Round 1 | (3) Round 2 | (4) Round 3 | (5) Round 4 |
|---|---|---|---|---|---|
| *Linear probability model:* | | | | | |
| demeaned baseline $SO_2$ ($\mu g/m^3$) | 0.00171 | 0.000150 | 0.00228 | 0.00274 | -0.00689 |
| | (0.53) | (0.02) | (0.33) | (0.36) | (-0.88) |
| demeaned announce $SO_2$ ($\mu g/m^3$) | -0.00201 | -0.000111 | -0.00254 | -0.00306 | 0.00772 |
| | (-0.56) | (-0.01) | (-0.33) | (-0.36) | (0.89) |
| log(pop_density) | 0.0331** | 0.000959 | 0.0399 | 0.0483 | -0.122*** |
| | (2.88) | (0.03) | (1.61) | (1.79) | (-4.37) |
| log(per_capita) | 0.000427 | -0.00780 | -0.0166 | -0.0182 | 0.0422 |
| | (0.03) | (-0.19) | (-0.49) | (-0.50) | (1.11) |
| Observations | 333 | 333 | 333 | 333 | 333 |
| *Logit model:* | | | | | |
| demeaned announce $SO_2$ ($\mu g/m^3$) | 0.0616 | 0.000707 | 0.0165 | 0.0167 | -0.0358 |
| | (0.61) | (0.02) | (0.35) | (0.38) | (-0.82) |
| demeaned baseline $SO_2$ ($\mu g/m^3$) | -0.0682 | -0.000522 | -0.0184 | -0.0187 | 0.0401 |
| | (-0.60) | (-0.01) | (-0.35) | (-0.38) | (0.84) |
| log(pop_density) | 1.560** | 0.00456 | 0.300 | 0.304 | -0.607*** |
| | (2.90) | (0.03) | (1.61) | (1.79) | (-4.09) |
| log(per_capita) | -0.299 | -0.0370 | -0.127 | -0.118 | 0.200 |
| | (-0.57) | (-0.19) | (-0.54) | (-0.54) | (0.97) |
| Observations | 333 | 333 | 333 | 333 | 333 |

Notes: Compares within-round using the 31-province sample. Announce $SO_2$ corresponds to the average $SO_2$ concentration in a city 1 to 6 weeks prior. Baseline $SO_2$ corresponds to the average $SO_2$ concentration in a city 7 to 12 weeks prior. t-statistics are shown in parentheses. *** p<0.01, ** p<0.05, * p<0.1

Table A.4: Difference-in-means and t-test statistics between plants in treated and control cities in the six-province entropy-balanced sample.

| | (1) Trial Round | (2) Round 1 | (3) Round 2 | (4) Round 3 | (5) Round 4 |
|---|---|---|---|---|---|
| log(per capita) | -0.0000642 | -0.0000133 | 0.000103 | 0.0000266 | 0.00000859 |
| | (-0.00) | (-0.00) | (0.00) | (0.00) | (0.00) |
| log(pop density) | 0.000707 | -0.00000350 | -0.000170 | -0.0000193 | 0.00000209 |
| | (0.01) | (-0.00) | (-0.00) | (-0.00) | (0.00) |
| log(distance to center) | -0.00000425 | -0.000000462 | -0.00000113 | 0.00000515 | 0.00000147 |
| | (-0.00) | (-0.00) | (-0.00) | (0.00) | (0.00) |
| revenue share city | -0.00117 | 0.00000305 | 0.000805 | -0.00000494 | -0.0000171 |
| | (-0.00) | (0.00) | (0.00) | (-0.00) | (-0.00) |
| log(company age) | -0.00168 | 0.0000617 | -0.000111 | -0.0000800 | -0.000134 |
| | (-0.00) | (0.00) | (-0.00) | (-0.00) | (-0.00) |
| Upper SOE | 0.0000363 | 0.00000333 | 0.0000588 | -0.00000408 | -0.00000900 |
| | (0.00) | (0.00) | (0.00) | (-0.00) | (-0.00) |
| Lower SOE | 0.0000707 | -0.00000631 | 0.0000492 | -3.83e-08 | 0.00000300 |
| | (0.00) | (-0.00) | (0.00) | (-0.00) | (0.00) |
| announce $SO_2$ ($\mu g/m^3$) | 0.00435*** | -0.00105 | -0.0217*** | 0.00523*** | 0.000964 |
| | (4.00) | (-1.68) | (-10.35) | (6.49) | (1.14) |
| baseline $SO_2$ ($\mu g/m^3$) | -0.00000226 | 0.000000103 | -0.0000566 | 0.000000320 | 2.69e-08 |
| | (-0.00) | (0.00) | (-0.01) | (0.00) | (0.00) |
| Observations | 973 | 973 | 973 | 973 | 973 |

Notes: Compares predictors of treatment using the entropy-balanced plant sample. Entropy balancing is conducted on characteristics observed prior to the start of an inspection. t-statistics are shown in parentheses. *** p<0.01, ** p<0.05, * p<0.1

Table A.5: Average effects of the announcement, on-site, and post-inspection periods in the entropy balanced and original samples, excluding plants that are permanently shut down following inspections.

| | **Short-term** | | **Medium-term** | | **Long-term** | | | |
|---|---|---|---|---|---|---|---|---|
| | EB | Original | EB | Original | EB | Original | EB | Original |
| | (1) $\log(SO_2)$ | (2) $\log(SO_2)$ | (3) $\log(SO_2)$ | (4) $\log(SO_2)$ | (5) $\log(SO_2)$ | (6) $\log(SO_2)$ | (7) $\log(SO_2)$ | (8) $\log(SO_2)$ |
| Announce | -0.056 | -0.042 | -0.042 | -0.029 | -0.061 | -0.028 | -0.057 | -0.026 |
| | (0.042) | (0.037) | (0.041) | (0.037) | (0.039) | (0.036) | (0.039) | (0.036) |
| On-site | -0.271*** | -0.271*** | -0.253*** | -0.284*** | -0.249*** | -0.277*** | -0.253*** | -0.279*** |
| | (0.046) | (0.044) | (0.039) | (0.038) | (0.038) | (0.035) | (0.038) | (0.035) |
| Post | -0.177*** | -0.165*** | -0.117*** | -0.103*** | -0.061*** | -0.046*** | -0.079*** | -0.067*** |
| | (0.038) | (0.029) | (0.025) | (0.017) | (0.019) | (0.013) | (0.020) | (0.013) |
| Elsewhere | 0.025 | 0.026** | 0.075*** | 0.053*** | 0.058*** | 0.051*** | 0.057*** | 0.050*** |
| | (0.017) | (0.013) | (0.020) | (0.015) | (0.018) | (0.013) | (0.019) | (0.014) |
| Post 12-23 wks | | | | | | | -0.020 | -0.012 |
| | | | | | | | (0.017) | (0.018) |
| Post 24-36 wks | | | | | | | 0.090** | 0.103*** |
| | | | | | | | (0.038) | (0.032) |
| Observations | 102,914 | 128,826 | 144,720 | 181,731 | 185,667 | 234,101 | 185,667 | 234,101 |
| R-squared | 0.710 | 0.743 | 0.708 | 0.737 | 0.700 | 0.726 | 0.701 | 0.727 |
| # of plants | 967 | 967 | 967 | 967 | 967 | 967 | 967 | 967 |
| Plant FE | Yes | Yes | Yes | Yes | Yes | Yes | Yes | Yes |
| Year FE | Yes | Yes | Yes | Yes | Yes | Yes | Yes | Yes |
| Week FE | Yes | Yes | Yes | Yes | Yes | Yes | Yes | Yes |

Notes: Six plants that were shut down permanently are omitted from the analysis. EB refers to estimates using the entropy-balanced sample. Baseline weeks (prior to the announcement period) are the omitted reference group. All specifications include plant, year, and week fixed effects. "Announce" refers to the announcement period, the earliest window during which a city would have learned inspectors were coming. "On-site" refers to the inspection period. "Post" refers to the period after the inspection ends. "Elsewhere" controls for an inspection underway in a non-focal province. All specifications control for plant, year, and week fixed effects, which would absorb the effect of time-invariant unobservable characteristics, plus annual policy or operational changes and seasonal fluctuations in electricity demand. Robust standard errors are given in parentheses. Standard errors are clustered at the city level. *** $p<0.01$, ** $p<0.05$, * $p<0.1$

Table A.6: Example of one complaint entry recorded for Xianning, Hubei Province.

| 受理编号 | 交办问题基本情况 | 涉及行政区 | 调查核实情况 | 是否属实 | 整改和问责情况 |
|---|---|---|---|---|---|
| D1211P058 | 赤壁市陆水大道99号华润电厂一号烟囱检修，现在使用临时附属烟囱，该烟囱只有10几米，排除的烟尘颗粒大，污染严重。信访人诉求：1.检查时从北门进入。2.从一号烟囱的树叶发现问题。3.咸宁市环境监察大队协助来检查。 | 赤壁市 | 因烟气脱硫塔鼓风风量与锅炉负荷高等问题导致12月4、5日个别时段废气排放异常，有飘散现象发生，加之临时烟囱较改造的240米主烟囱低很多，致使临近厂区居民点有散落的白灰。现场核查该公司#1、#2、#3、#4机组废气在线监测数据，4台炉的废气、烟尘均达标排放，对该公司#1机组临时排放污染物进行人工对比监测，数据结果显示烟尘、二氧化硫、氮氧化物等排放物均为达标。12月13日，咸宁市环保执法人员会同赤壁市环保执法人员对该公司信访交办件中反映的问题进行现场调查核实，该公司北门早已封闭，厂区#1机组北门内外周边树叶没有附着烟尘颗粒污染物。 | 属实 | 要求该公司1#机组运行负荷控制在210MW，低于65%以下，污染物排放在项目改造期间要稳定达标，并接受执法部门和周边群众的监督，如果再次发生飘浆现象将立即停止#1机组改造项目期间的运行。将进一步加强对华润电力湖北有限公司的环境监管。加强企业废气超洁净改造期间废气排放的现场环境管理。督促企业主动公开环境信息，定期向周边群众代表开放，让老百姓了解该公司污染物治理和排放的具体情况。 |

(a) Chinese version.

| File Number | Detailed Complaint | Location | Investigation Report | True/Not | Punishment and Feedback |
|---|---|---|---|---|---|
| D1211P058 | The No. 1 chimney of China Resources Power Plant, located at No. 99 Lushui Avenue, Chibi County, is now being repaired. A temporary chimney is being used as a replacement. This chimney is only 10 meters long. The smoke particles emitted are large, resulting in serious pollution. The petitioner appeals: 1. Inspection team should enter from the north gate during the random check-up. 2. The inspection team may identify the problem by checking tree leaves near the No. 1 chimney. 3. The Xianning Environmental Protection Bureau should assist in the inspection. | Chibi County, Xianning City | Due to the high quantity in blast air volume and boiler load of the flue gas desulfurization tower, on December 4$^{\text{th}}$ and 5$^{\text{th}}$, exhaust emissions were abnormal in some periods. Given the slurry drift phenomenon and low height of the temporary chimney (much lower than the 240-meter main chimney), scattered white ash was found in neighboring residencies. During the on-site inspection, the team checked real-time monitoring data of the #1, #2, #3, and #4 generating units of the company. The exhaust gas and soot emissions of the four furnaces all met standards. The inspection team also manually measured the pollutants discharged from the #1 generation unit. The data showed that emissions such as soot, sulfur dioxide, and nitrogen oxides all met standards. On December 13th, EPB officials from Xianning City and EPB officials from Chibi County conducted an on-the-spot investigation to verify the complaint. The north gate of the company has been closed, and tree leaves around 1# generation unit do not have any smoke particulates attached. | True | It is required that the operating load of the #1 generation unit should be within 210MW, and less than 65%. Pollutant discharge standards should be met during the reconstruction period. The company should be constantly supervised by the local EPB and the surrounding citizens. If the slurry drift phenomenon occurs again, operation of the #1 generation unit will be stopped immediately. The environmental supervision of China Resources Power Hubei Co., Ltd. will be further strengthened. EPB urges the enterprise to disclose environmental information on its own initiative, and open to the surrounding citizens on a regular basis so that people are aware of the situation of the company's pollutant treatment and emissions. |

(b) English version.

Table A.7: Summary statistics of complaints received by province for the entire country.

| Province name | Inspec round | GDP (BN) | Pop (MN) | Per-cap GDP | Closed cases | Person detained | Person intvwed | Officials account | Case per mil person |
|---|---|---|---|---|---|---|---|---|---|
| Hebei | 0 | 3207 | 63 | 51108 | 2856 | 123 | 65 | 366 | 45 |
| Guangxi | 1 | 1832 | 41 | 45032 | 2341 | 10 | 204 | 351 | 57 |
| Heilongjiang | 1 | 1539 | 32 | 48272 | 1226 | 28 | 32 | 560 | 38 |
| Henan | 1 | 4047 | 80 | 50501 | 2682 | 31 | 148 | 1231 | 34 |
| Jiangsu | 1 | 7739 | 67 | 115508 | 2451 | 108 | 618 | 449 | 37 |
| Jiangxi | 1 | 1850 | 39 | 47955 | 1050 | 57 | 220 | 124 | 27 |
| Nei Mongol | 1 | 1813 | 21 | 85769 | 1637 | 57 | 238 | 280 | 78 |
| Ningxia Hui | 1 | 317 | 6 | 55923 | 476 | 8 | 35 | 105 | 79 |
| Yunnan | 1 | 1479 | 40 | 36841 | 1234 | 11 | 681 | 322 | 31 |
| Beijing | 2 | 2567 | 18 | 141568 | 2346 | 28 | 624 | 45 | 130 |
| Chongqing | 2 | 1774 | 26 | 69408 | 1824 | 16 | 64 | 40 | 70 |
| Gansu | 2 | 720 | 22 | 32789 | 1984 | 32 | 744 | 836 | 90 |
| Guangdong | 2 | 8085 | 92 | 87784 | 4350 | 118 | 1252 | 684 | 47 |
| Hubei | 2 | 3267 | 49 | 66146 | 1925 | 28 | 945 | 522 | 39 |
| Shaanxi | 2 | 1940 | 32 | 60597 | 1309 | 26 | 492 | 938 | 41 |
| Shanghai | 2 | 2818 | 20 | 139581 | 1893 | 17 | 545 | 56 | 95 |
| Anhui | 3 | 2441 | 52 | 46887 | 3719 | 63 | 637 | 476 | 72 |
| Fujian | 3 | 2881 | 32 | 88719 | 4903 | 31 | 991 | 444 | 153 |
| Guizhou | 3 | 1178 | 30 | 39367 | 3453 | 32 | 1170 | 321 | 115 |
| Hunan | 3 | 3155 | 57 | 55054 | 4583 | 174 | 1382 | 1359 | 80 |
| Liaoning | 3 | 2225 | 37 | 60671 | 6991 | 32 | 581 | 850 | 189 |
| Shanxi | 3 | 1305 | 31 | 42221 | 3582 | 61 | 1589 | 1071 | 116 |
| Tianjin | 3 | 1789 | 13 | 137095 | 4226 | 12 | 307 | 139 | 325 |
| Hainan | 4 | 405 | 8 | 52653 | 1792 | 49 | 392 | 291 | 224 |
| Jilin | 4 | 1478 | 23 | 64401 | 7968 | 50 | 614 | 1324 | 346 |
| Qinghai | 4 | 257 | 5 | 51584 | 2299 | 30 | 195 | 184 | 460 |
| Shandong | 4 | 6802 | 83 | 81502 | 8170 | 76 | 1186 | 1268 | 98 |
| Sichuan | 4 | 3293 | 69 | 47417 | 8966 | 48 | 1294 | 1293 | 130 |
| Xinjiang Uygur | 4 | 965 | 20 | 47854 | 2905 | 25 | 163 | 1613 | 145 |
| Xizang | 4 | 115 | 3 | 41284 | 1020 | 2 | 232 | 148 | 340 |
| Zhejiang | 4 | 4725 | 47 | 100898 | 6920 | 144 | 779 | 350 | 147 |
| Total | | | | | 103081 | 1527 | 18419 | 18040 | |

Table A.8: Effects on $NO_X$ at plants during the announcement, on-site, and post-inspection periods.

| | Short-term | Medium-term | Long-term | |
|---|---|---|---|---|
| | (1) log($NO_X$) | (2) log($NO_X$) | (3) log($NO_X$) | (4) log($NO_X$) |
| Announce | -0.026 | -0.022 | -0.025 | -0.026 |
| | (0.019) | (0.019) | (0.019) | (0.019) |
| On-site | -0.068** | -0.061** | -0.086*** | -0.084*** |
| | (0.031) | (0.030) | (0.031) | (0.030) |
| Post | 0.039** | 0.046*** | 0.015 | 0.023* |
| | (0.016) | (0.014) | (0.012) | (0.012) |
| Elsewhere | -0.005 | -0.004 | -0.010 | -0.009 |
| | (0.012) | (0.013) | (0.012) | (0.011) |
| Post 12-23 wks | | | | 0.030** |
| | | | | (0.012) |
| Post 24-36 wks | | | | -0.063*** |
| | | | | (0.018) |
| Observations | 102,281 | 144,269 | 185,793 | 185,793 |
| R-squared | 0.689 | 0.688 | 0.680 | 0.681 |
| Number of plants | 769 | 769 | 769 | 769 |
| Plant FE | Yes | Yes | Yes | Yes |
| Year FE | Yes | Yes | Yes | Yes |
| Week FE | Yes | Yes | Yes | Yes |

Notes: Uses the original power plant sample. $NO_X$ is a proxy for plant power output. All plants included in our subsample do not have $NO_X$ scrubbers installed, to ensure that any changes in $NO_X$ levels are due to fluctuations in plant output. Standard errors are clustered at the city level. *** p<0.01, ** p<0.05, * p<0.1

Table A.9: Effect of inspections interacted with a firm's Upper SOE status in the on-site and post-inspection periods.

| | (1) log($SO_2$) | (2) log($SO_2$) | (3) log($SO_2$) | (4) log($SO_2$) | (5) log($SO_2$) |
|---|---|---|---|---|---|
| Announce | -0.028 | -0.028 | -0.028 | -0.028 | -0.028 |
| | (0.036) | (0.036) | (0.036) | (0.036) | (0.036) |
| On-site | -0.280*** | -0.279*** | -0.280*** | -0.280*** | -0.280*** |
| | (0.035) | (0.035) | (0.035) | (0.035) | (0.035) |
| Post 0-11 wks | -0.163*** | -0.163*** | -0.186*** | -0.163*** | -0.163*** |
| | (0.031) | (0.031) | (0.037) | (0.031) | (0.031) |
| Post 12-23 wks | -0.077*** | -0.077*** | -0.077*** | -0.068*** | -0.077*** |
| | (0.021) | (0.021) | (0.021) | (0.022) | (0.021) |
| Post 24-36 wks | 0.042 | 0.042 | 0.042 | 0.042 | 0.048 |
| | (0.028) | (0.028) | (0.028) | (0.028) | (0.031) |
| Elsewhere | 0.046*** | 0.046*** | 0.046*** | 0.046*** | 0.046*** |
| | (0.013) | (0.013) | (0.013) | (0.013) | (0.013) |
| On-site × USOE | | -0.002 | | | |
| | | (0.038) | | | |
| Post 0-11 wks × USOE | | | 0.068* | | |
| | | | (0.038) | | |
| Post 12-23 wks × USOE | | | | -0.024 | |
| | | | | (0.022) | |
| Post 24-36 wks × USOE | | | | | -0.015 |
| | | | | | (0.037) |
| Observations | 235,682 | 235,682 | 235,682 | 235,682 | 235,682 |
| R-squared | 0.728 | 0.728 | 0.728 | 0.728 | 0.728 |
| Number of plants | 973 | 973 | 973 | 973 | 973 |
| Plant FE | Yes | Yes | Yes | Yes | Yes |
| Year FE | Yes | Yes | Yes | Yes | Yes |
| Week FE | Yes | Yes | Yes | Yes | Yes |

Notes: Uses the original power plant sample. USOE - Upper SOE. Coefficient estimates are average effects within multi-week periods, relative to the inspection. Baseline weeks (prior to the announcement period) are the omitted reference group. "Announce" refers to the announcement period, the earliest window during which a city would have learned inspectors were coming. "On-site" refers to the inspection period. "Post" refers to the period after the inspection ends. "Elsewhere" controls for an inspection underway in a non-focal province. Regression is the full interaction of Upper SOE status with covariates. The interaction between ownership/oversight status and Post periods of varying length captures variation in the post-inspection response by ownership/oversight level. All specifications include plant, year, and week fixed effects. All specifications control for plant, year, and week fixed effects, which would absorb the effect of time-invariant unobservable characteristics, plus annual policy or operational changes and seasonal fluctuations in electricity demand. Robust standard errors are given in parentheses. Standard errors are clustered at the city level. *** p<0.01, ** p<0.05, * p<0.1

Table A.10: Direct effect of campaign with interactions on scrubber technology in different post periods by plant oversight.

| | All | USOE | LSOE | Private |
|---|---|---|---|---|
| | (1) log($SO_2$) | (2) log($SO_2$) | (3) log($SO_2$) | (4) log($SO_2$) |
| Announce | -0.028 | -0.041 | 0.002 | -0.038 |
| | (0.036) | (0.040) | (0.060) | (0.033) |
| On-site | -0.280*** | -0.255*** | -0.273*** | -0.303*** |
| | (0.035) | (0.045) | (0.045) | (0.036) |
| Post 0-11 wks | -0.278*** | -0.329*** | -0.227*** | -0.264*** |
| | (0.039) | (0.076) | (0.051) | (0.040) |
| Post 12-23 wks | -0.077*** | -0.096*** | -0.072** | -0.054** |
| | (0.021) | (0.025) | (0.029) | (0.021) |
| Post 24-36 wks | 0.043 | 0.034 | 0.038 | 0.044 |
| | (0.028) | (0.030) | (0.034) | (0.032) |
| Elsewhere | 0.046*** | 0.064*** | 0.043** | 0.037** |
| | (0.013) | (0.014) | (0.016) | (0.016) |
| Post 0-11 wks × $SO_2$ Scrubber | 0.145*** | 0.240*** | 0.061 | 0.095*** |
| | (0.034) | (0.074) | (0.058) | (0.035) |
| Observations | 235,682 | 81,368 | 40,478 | 109,756 |
| R-squared | 0.728 | 0.715 | 0.730 | 0.732 |
| Number of plants | 973 | 334 | 157 | 465 |
| Plant FE | Yes | Yes | Yes | Yes |
| Year FE | Yes | Yes | Yes | Yes |
| Week FE | Yes | Yes | Yes | Yes |

Notes: Uses the original power plant sample. USOE - Upper SOE, LSOE - Lower SOE. Column (2) includes only upper SOE firms (state-owned enterprises with national-level or provincial-level oversight). Column (3) includes only firms that are lower SOE (state-owned enterprises with city-level or county-level oversight). Column (4) uses only firms that are private enterprises. Coefficient estimates are average effects over multi-week periods. Baseline weeks (prior to the announcement period) are the omitted reference group. "Announce" refers to the announcement period, the earliest window during which a city would have learned inspectors were coming. "On-site" refers to the inspection period. "Post" refers to the period after the inspection ends. "Elsewhere" controls for an inspection underway in a non-focal province. All specifications control for plant, year, and week fixed effects, to absorb the effect of time-invariant unobservable characteristics, plus annual policy or operational changes and seasonal fluctuations in electricity demand. Robust standard errors are given in parentheses. Standard errors are clustered at the city level. *** p<0.01, ** p<0.05, * p<0.1

Table A.11: Effect of inspections with interactions on scrubber technology in different post period by plant capacity (MW).

| | All | Cap ≤ 100 MW | 100 MW < Cap ≤1000 MW | Cap >1000 MW |
|---|---|---|---|---|
| | (1) log($SO_2$) | (2) log($SO_2$) | (3) log($SO_2$) | (4) log($SO_2$) |
| Announce | -0.028 | -0.006 | -0.061 | -0.032 |
| | (0.036) | (0.039) | (0.037) | (0.038) |
| On-site | -0.280*** | -0.270*** | -0.322*** | -0.248*** |
| | (0.035) | (0.043) | (0.042) | (0.040) |
| Post 0-11 wks | -0.278*** | -0.258*** | -0.330*** | -0.265* |
| | (0.039) | (0.049) | (0.056) | (0.147) |
| Post 12-23 wks | -0.077*** | -0.071*** | -0.081*** | -0.083** |
| | (0.021) | (0.021) | (0.025) | (0.032) |
| Post 24-36 wks | 0.043 | 0.009 | 0.100*** | 0.069** |
| | (0.028) | (0.028) | (0.038) | (0.030) |
| Elsewhere | 0.046*** | 0.034** | 0.069*** | 0.064*** |
| | (0.013) | (0.015) | (0.014) | (0.018) |
| Post 0-11 wks × $SO_2$ Scrubber | 0.145*** | 0.139*** | 0.181*** | 0.140 |
| | (0.034) | (0.039) | (0.055) | (0.147) |
| Observations | 235,682 | 136,104 | 68,946 | 29,569 |
| R-squared | 0.728 | 0.728 | 0.722 | 0.745 |
| Number of plants | 973 | 571 | 282 | 116 |
| Plant FE | Yes | Yes | Yes | Yes |
| Year FE | Yes | Yes | Yes | Yes |
| Week FE | Yes | Yes | Yes | Yes |

Notes: Uses the original power plant sample. Column (2) includes only firms with electricity production capacity ≤ 100 MW. Column (3) includes only firms with electricity production capacity > 100 MW and ≤ 1000 MW. Column (4) includes only firms with electricity production capacity > 1000 MW. Coefficient estimates are average effects over multi-week periods. Baseline weeks (prior to the announcement period) are the omitted reference group. "Announce" refers to the announcement period, the earliest window during which a city would have learned inspectors were coming. "On-site" refers to the inspection period. "Post" refers to the period after the inspection ends. "Elsewhere" controls for an inspection underway in a non-focal province. All specifications control for plant, year, and week fixed effects, to absorb the effect of time-invariant unobservable characteristics, plus annual policy or operational changes and seasonal fluctuations in electricity demand. Robust standard errors are given in parentheses. Standard errors are clustered at the city level. *** $p<0.01$, ** $p<0.05$, * $p<0.1$

Table A.12: Effect of inspections with interactions on plants receiving a complaint.

| | (1) log($SO_2$) | (2) log($SO_2$) | (3) log($SO_2$) | (4) log($SO_2$) |
|---|---|---|---|---|
| Announce | -0.030 | -0.044 | -0.044 | -0.044 |
| | (0.039) | (0.038) | (0.038) | (0.038) |
| On-site | -0.272*** | -0.254*** | -0.272*** | -0.272*** |
| | (0.044) | (0.047) | (0.044) | (0.044) |
| Post | -0.166*** | -0.166*** | -0.161*** | -0.161*** |
| | (0.029) | (0.029) | (0.029) | (0.029) |
| Elsewhere | 0.025* | 0.025* | 0.025* | 0.025* |
| | (0.013) | (0.013) | (0.013) | (0.013) |
| Announce × Complaint | -0.052** | | | |
| | (0.024) | | | |
| On-site × Complaint | | -0.068** | | |
| | | (0.026) | | |
| Post × Complaint | | | -0.020 | -0.038 |
| | | | (0.021) | (0.024) |
| Post × Complaint × USOE | | | | 0.054 |
| | | | | (0.041) |
| Observations | 129,697 | 129,697 | 129,697 | 129,697 |
| R-squared | 0.744 | 0.744 | 0.744 | 0.744 |
| Number of plants | 973 | 973 | 973 | 973 |
| Plant FE | Yes | Yes | Yes | Yes |
| Year FE | Yes | Yes | Yes | Yes |
| Week FE | Yes | Yes | Yes | Yes |

Notes: Uses the original power plant sample. USOE - Upper SOE. Sample used in this table only spans to "Post 0-11 wks", that is until 12 weeks after the inspection ends. Coefficient estimates are average effects within multi-week periods, relative to the inspection. Baseline weeks (prior to the announcement period) are the omitted reference group. "Announce" refers to the announcement period, the earliest window during which a city would have learned inspectors were coming. "On-site" refers to the inspection period. "Post" refers to the period after the inspection ends. "Elsewhere" controls for an inspection underway in a non-focal province. In columns (1)-(3), the periods defined by the inspection ("Announce," "On-site," and "Post") are interacted with complaint status (equal to one if a plant receives a complaint, and otherwise zero). In column (4), complaint status is further interacted with Upper SOE status. All specifications include plant, year, and week fixed effects. All specifications control for plant, year, and week fixed effects, which would absorb the effect of time-invariant unobservable characteristics, plus annual policy or operational changes and seasonal fluctuations in electricity demand. Robust standard errors are given in parentheses. Standard errors are clustered at the city level. *** $p<0.01$, ** $p<0.05$, * $p<0.1$