Local official and polluter accountability in China's environmental inspections

by
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Abstract

Poor environmental practices can lead to high levels of ambient air pollution that are detrimental to human health and cause premature death. Even if environmental regulations are well designed, incomplete implementation at the local level imposes substantial significant social costs. Although widely documented, solutions to inadequate enforcement have not been comprehensively studied. Using the context of China's environmental inspections, I examine which interventions effectively reduce air pollution in Chinese cities and close the enforcement gap. I am particularly interested in interventions that aim to alter the behavior of polluting company managers and local environmental bureaucrats.

In this thesis, I evaluate China's "new" hybrid approach, environmental inspections, that combines top-down scrutiny with bottom-up reporting. First, I investigate the dynamic responses of polluters to central scrutiny, which is a sharp, temporary increase in regulatory enforcement. Using data from China that links the intensity of environmental policing to high-frequency air pollution data, I show that crackdown over short (one-month) periods results in a sharp (35-39%) reduction in weekly average pollution around coal power plants. Pollution gradually reverts to prior levels after crackdowns end. The pace of reversion is faster for firms that outrank the city government, suggesting that hierarchical ties to China's central authorities limit a firm's accountability to the local environmental protection bureau.

Second, I present a full account of the citizen complaints received during the environmental inspection and evaluate the incremental effectiveness of the complaint channel on plant's environmental performance. I build a novel data set that includes all complaint entries filed by citizens. I describe the frequency of complaints received by a wide range of polluters during the campaign, from small barbecue stalls to large aluminum smelters, suggesting that citizens focus on the most salient pollution sources in their immediate surroundings. Engaging citizen informants during crackdowns is not associated with larger pollution reductions but has no lasting effect, especially for the outranking firms. I further explore the effectiveness of such approach in a repeated version as the same program is conducted nationwide two years after the initial round. I find diminishing effects of top-down scrutiny as plants learn and update their beliefs on the seriousness of the campaign. However, direct central attention to these outranking firms during the lookback round may prolong the environmental inspection effect.

Third, I ask what drives citizen engagement in a central-initiated monitoring program in an authoritarian regime. I identify city and plant characteristics that predict the number of per capita complaints. Cities with poor environmental performance at the outset receive a greater number of complaints during both rounds of the environmental inspection. However, citizens can not identify and report egregious plants that polluted more in the baseline period. In addition, the willingness of citizens to file complaints is contingent on the environmental effectiveness of the original round. At the city level, the number of air-related complaints received per capita during the lookback round will decrease if measured air pollutants return to their baseline pollution levels following the conclusion of the original round.

This dissertation empirically documents the limits of China's highly centralized, state-led approach to improving environmental governance through enforcement crackdowns and engaging citizen complaints.

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Chapter 1

Introduction

1.1 Background

Weak regulatory enforcement can impede government efforts to improve environmental quality in industrializing countries. Despite regulations and pressure from the central government and outcry from the citizen, there are frequent cases of inadequate policy enforcement at the local level. Researchers have categorized such an implementation failure as an "enforcement gap" – the inconsistency between regulations on the book and actual practices (Lo et al., 2012; McAllister et al., 2010). High pollution, especially in developing countries, has been linked to the enforcement gap. Despite extensive evidence of inadequate enforcement of environmental regulations (Duflo et al., 2018; Shimshack, 2014), it is not well understood which interventions are effective at overcoming these implementation failures.

There are two schools of thought about the causes of incomplete implementation of well-crafted environmental regulations. First, inadequate state capacity (such as a lack of resources, manpower, and financing, particularly at the local level) inhibits the full implementation of environmental regulations (Van Rooij, 2006; Kostka, 2014). In developing nations with inadequate expertise and public resources to assist policy enforcement, these flaws may be extremely significant. If a polluting company's private cost of compliance exceeds the estimated cost of noncompliance,[1] it may fail to comply or fabricate compliance. Policy prescriptions aimed at enhancing local officials' capacity to identify and punish infractions may be beneficial in bridging the enforcement gap and facilitating long-term pollution reductions. Second, motivational or incentive-based antecedents may result in poor environmental performance. Duflo et al. (2013) uncover evidence that firms in Pakistan colluded with private auditors to exaggerate their environmental performance. In China, the largest discrepancies between self-reported firm and independent satellite measurements of pollution occurred in regions subject to the highest near-term policy pressure (Karplus et al., 2018). These examples demonstrate that norms governing interactions between firms and the state (Hallward-Driemeier and Pritchett, 2015) may influence corporate compliance decisions. In contrast to industrialized democracies, where regulatory compliance is well described (Gray and Shimshack, 2020), the absence of institutionalized channels for shareholder feedback may result in vastly different norms in developing nations.

In China, environmental regulatory enforcement is exceptionally lax. Prior literature has criticized China's authoritarian approach to environmental protection as incapable of achieving its goals in practice. Historically, environmental and energy policies have been shown to suffer from weak implementation capacity and perverse incentives (Steinfeld et al., 2009; Xu, 2011; Kostka, 2014). Environmental taxes were unevenly collected (Ma and Ortolano, 2000), local governments protected rather than penalized polluters (Van Rooij, 2006), and economic development superseded environmental protection on national policy objectives for decades (Kostka, 2014). Causes for inadequate enforcement of environmental regulations at the local level are a combination of both narratives. Consistent with the capacity-building arguments, local bureaucrats lack the monitoring and organizational capacity to implement environmental regulations (Marks, 2010; Lo et al., 2006). Consistent with the incentive-alignment hypothesis, local officials deemphasize environmental performance to the

[1] Cost of noncompliance should be computed as the amount of fine multiplied by the likelihood that it will be enforced multiplied by the likelihood of detection.

extent it conflicts with economic growth (Xu, 2011).

This dissertation examines the effectiveness of China's environmental inspection, a central-initiated effort to scrutinize local governments and engage citizens, in bridging the enforcement gap. I quantify its environmental impact using high-frequency air pollution data. In 2015, the central government of China began a nationwide program encouraging citizens to report egregious polluters within a province during specified one-month periods. Simultaneously, the behavior and administrative duties of environmental officials in that province were extensively examined. I evaluate the ability of this hybrid method to induce long-lasting changes in polluter behavior by measuring the changes in ambient air pollutant levels over time at coal power plants and study whether allowing citizens to report on polluters during inspections prolongs cleanup.

Although the subject of this thesis is China's air pollution problem, the "enforcement gap" is not limited to authoritarian regimes or the air quality issue. In regions with limited administrative capacity and poor regulatory compliance (particularly industrializing countries), environmental regulations and other policies designed to address externalities are usually given a lesser priority than those addressing material concerns. Environmental pollution is only one area in which inadequate enforcement of regulations results in welfare losses and a delay in addressing sustainability concerns. Similar examples may be found in labor law compliance in Brazil (Davies and Vadlamannati, 2013), tax collection in Malaysia (Hasnan et al., 2013), and product safety management in the European Union (Majone, 1994). Using the context of China's environmental inspections, I examine the effect of temporarily closing the enforcement gap on pollution levels at targeted firms. These experiences can help government authorities devise initiatives to address the problem of enforcement.

1.1.1 Analytical framework: Two accountability routes

To determine which interventions are effective in altering the behavior of local polluters, I study the accountability triangle developed in the World Bank (2004). As shown in Figure 1-1, it connects citizens to public service providers. Under the principal-agent framework, it proposes two "accountability routes" in which citizens are the ultimate principals demanding performance in service delivery. On the "long route" to accountability (red directions in Figure 1-1), citizens exercise their "principal" rights by first influencing political representatives (e.g., via elections), who then govern bureaucracies by delegating authority to local officials, who in turn supervise the work of front line service providers. In contrast, on the "short route" to accountability (blue direction in Figure 1-1), citizens directly demand service from local service providers.

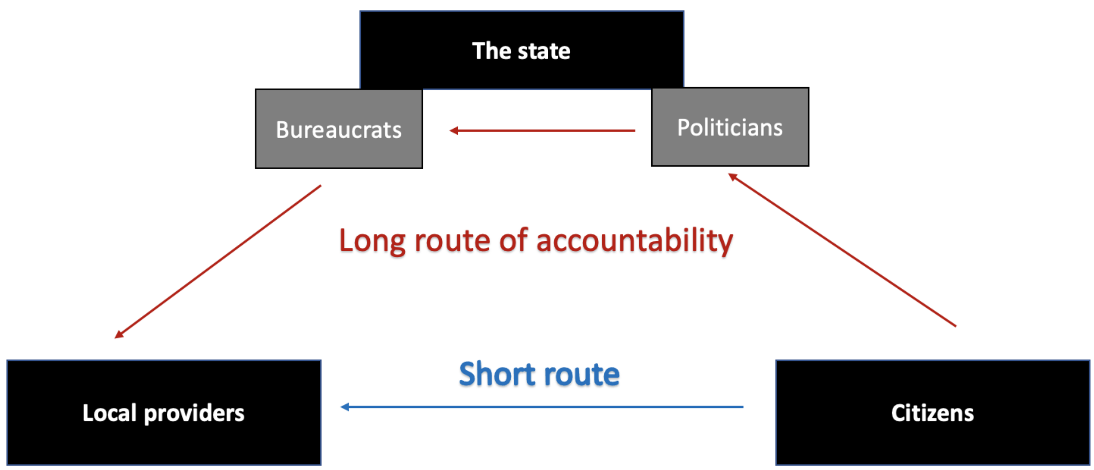


Figure 1-1: The framework of accountability relationships.

China's environmental governance is an example of the long accountability route, in which citizens are the ultimate principal demanding environmental performance from the agent (local polluters). Figure 1-2 depicts the long accountability route from citizens to the state and subsequently to the polluters as solid red directions. The central government designs environmental policies and regulations in response to growing environmental quality related concerns and protests. These citizen actions may be perceived as a threat to the regime's stability. Lacking the capacity to monitor local enforcement, the central government delegates its power to local bureaucrats, who implement these environmental regulations under direct supervision from the central government. This dissertation examines the effectiveness of the long accountability route in regulating local bureaucrats and polluters to comply with environmental regulations, as well as its benefits on reducing local environmental pollution. However, the short route to accountability, illustrated as the blue dashed directions in Figure 1-2, is not investigated in this dissertation. Large polluting sectors in China, such as power, iron, and steel, are predominantly state-controlled monopolies. Consequently, environmental quality in China is highly dependent on policies made by the central governmental. Due to the absence of "choice" available in a liberalized market, citizens lack the purchasing power to influence the conduct of local polluters.

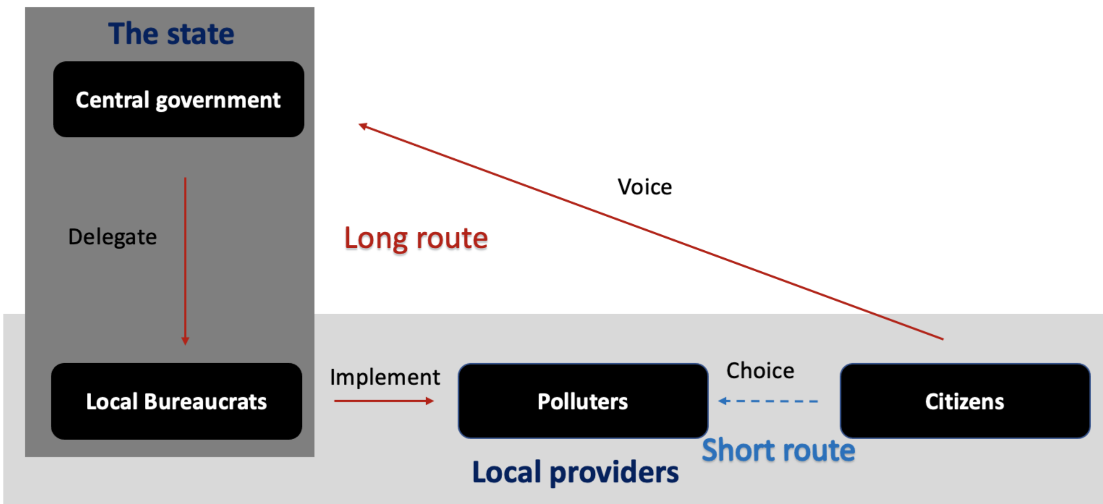


Figure 1-2: The framework describing how China enforces environmental regulations.

Long accountability route requires two parts to be effective. First, citizens are empowered to exert influence over the state's policy-making process. And governmental policy must represent the best interests of the general public ("Voice" in Figure 1-2). In China, however, there are no institutionalized channels for stakeholder feedback, making it hard to hold the central government and local authorities accountable for poor performance through elections or collective actions. Chapter 4 focuses on this component and examines what motivates citizens to voice their concerns to the central state and and what steps might be taken to ensure that developed policies represent citizens' interests. Second, the central state may hold local bureaucrats and polluters accountable if regulations are not implemented and expected outcomes are not attained. Chapters 2 and 3 identify challenges in this part and ask what obstacles the central state may have to overcome to ensure that local officials and polluting firms managers implement environmental regulations and are held accountable for their actions if they do not.

1.1.2 Empirical setting: China's rotating environmental inspection

In late 2015 the Chinese central government announced rotating inspections (*huanbao ducha* in Chinese) to strengthen enforcement by city environmental protection bureaus against polluting firms. Inspection teams were dispatched to oversee how local bureaucrats implement environmental regulations on polluters, shown in Figure 1-3. These inspections constitute an example of the top-down accountability, during which an informal institution temporarily increases central oversight of the local periphery. Another key aspect of the environmental inspection is that central government officials enlist local citizens to help identify polluters and encourage reporting through telephone hotlines and mailboxes during their stay in a province. Complaints are forwarded to the city environmental protection bureau for verification and follow-up, while the central inspection team oversees the process. Inspection teams were re-deployed in 2018 for a "look back" (*huotou kan* in Chinese) round to evaluate progress in addressing violations discovered in the original round, and central officials announced plans to conduct subsequent rounds on a biannual basis.

Historiography informs China's centralized campaign-style approach to raising enforcement practice. In the Qing and early Ming dynasties, the Imperial Commissioners, representing the emperors, were dispatched to localities in reaction to large-scale natural catastrophes or to assess the performance of local authorities. After the foundation of People's republic of China, "work teams" were assigned to localities to guarantee the implementation of national-level policies, such as the one child policy (Perry, 2019; Li, 1995). China's environmental inspections are a contemporary illustration of this approach. Despite being well-documented in historical literature,

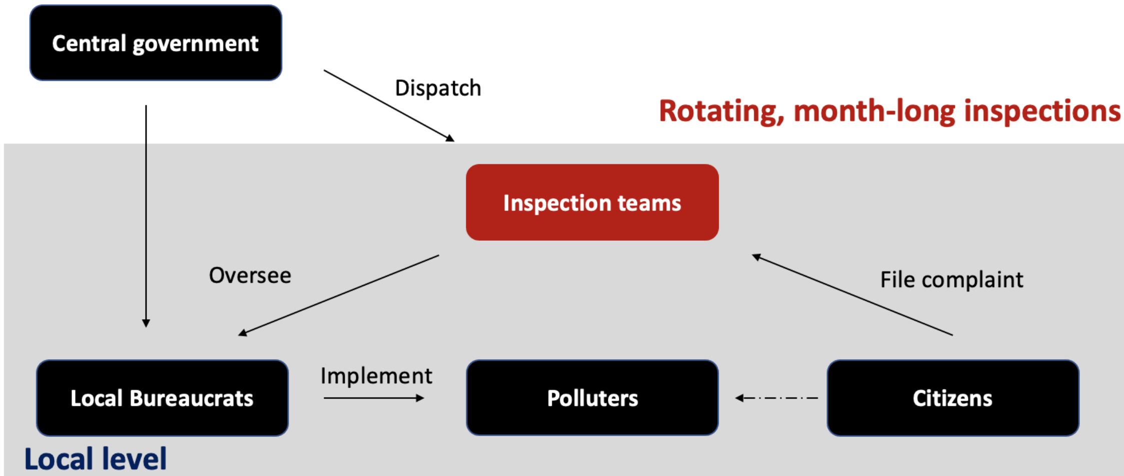


Figure 1-3: The organizational structure of China's environmental inspections

the effects of this approach have never been empirically studied. This dissertation measures the impact of this approach in reducing local environmental pollution using high-frequency air pollution data.

1.1.3 Theoretical framework: The "principal-agent" problem

What factors contribute to the inadequate implementation of central-designed environmental regulations at the local level? Why can not the central government hold the bureaucracy accountable in case of deviations? I analyze bureaucratic behaviors using the "principal-agent" framework: the principal (central government) designs a program with a certain objective in mind, and the agents (local bureaucrats) carry it out (Banerjee et al., 2012; Dhaliwal and Hanna, 2017). Nonetheless, this political contract between the central state and local bureaucrats may be undermined by a number of challenges: first, information asymmetries (Epstein and O'halloran, 1994; Moe, 1985) between the central and local governments, as the central government does not have the ability to monitor bureaucrats' behavior perfectly. Second, misaligned incentives (Banerjee, 1997; Rose-Ackerman, 1986) as bureaucrats may have different incentives than the government in the way they administer the program. Third, multi-tasking problem (Holmstrom and Milgrom, 1991; Bénabou and Tirole, 2006) as local bureaucrats usually undertake multiple tasks, and some dimensions of the performance outcome can not be effectively monitored and measured. Below, I discuss in detail how these challenges create the gap between the central government's environmental policy and its local implementation outcomes. I look for evidence of whether China's environmental inspection program resolves some of the challenges.

First, Scholz and Wei (1986) and Olson (1999) find evidence of information asymmetries between politicians and bureaucrats in the U.S. context. In an authoritarian regime, information asymmetries are ubiquitous due to the absence of democratic institutions, such as free media and elections, that may report and aggregate information. Kostka and Nahm (2017) emphasize the difficulties in gathering credible information on the implementation of environmental programs in China. China's environmental inspection provides an empirical setting to test the effectiveness of enhanced information collection on polluting industry compliance. During the on-site inspection, the central team conducts interviews with local officials and carries out spot checks on firms. All contribute to bridging the information gap between the central and local environmental protection bureaucrats. In addition to top-down inspection, the program supports bottom-up monitoring by developing channels for citizens to report egregious pollutants in their neighborhood, which may act as an additional information-gathering mechanism.

Second, local bureaucrats have misaligned incentives with full implementation of environmental policies designed by the central government (Ran, 2013) both in terms of career advancement and financial budgeting. Unlike a democratic system where the political motive for local bureaucrats is to fulfill constituents' preferences and obtain additional votes, local government officials in China are directly selected and appointed by the Party committee. The tournament competition model for promotion (Maskin et al., 2000) rewards local leaders based on easily quantifiable and attributable "hard target" (Li and O'brien, 2008), which is biased toward economic measures. Since the benefits of environmental quality are diffuse, and the outcomes are difficult to quantify, local governments prioritize activities that generate economic output when they conflict with economic growth. Moreover, local government officials acquire a greater proportion of the private benefits of economic growth, e.g., through tax revenues, capital investment, and employment. Occasionally, they even turn a blind eye to businesses that create excessive pollution due to their tax contributions (Ran, 2013; Alkon and Wong, 2020). One way to better align the incentives of local bureaucrats with those of the central government would be to increase the penalties associated with weak implementation of environmental policies, whether in the form of monetary fines or stigma that affects one's career trajectory. China's environmental inspection allows us to test such hypothesis. Local authorities' performance was assessed by the central inspection teams, who held them accountable for inadequate environmental protection activities. With the increase in the probability of detection and sanctioning for poor implementation of environmental policies (Lipsky, 1980; Cilliers et al., 2018), local bureaucrats become more motivated to implement central targets fully.

Third, in a multi-tasking environment, agents are incentivized to divert their attention from less weighted and less quantifiable tasks (Tsui and Wang, 2004). In the Chinese context, local bureaucrats face the conflicting dual objectives of generating economic output and enforcing environmental protection. Cao et al. (2021) study this multi-tasking challenge faced by local Chinese officials to meet minimum air quality control targets while promoting economic development. They find evidence that air quality significantly deteriorates once the target is guaranteed. Local officials gain little from over-fulfillment of targets but incur significant costs by crowding out the efforts to promote economic growth, which is directly linked to their career advancement opportunities. China's environmental inspection provides a comparable setting for analyzing the performance of local agents when faced with obligatory objectives under central oversight. During the onsite period, local officials have to fulfill minimum environmental targets, or lose their chance of promotion or even being removed from their posts.

Chapters 2 and 3 find strong evidence that air quality improves when the central inspection teams are physically onsite but deteriorates significantly after they leave the locality. These responses indicate that environmental inspection may be viewed as a one-time shock to enhance the frequency and stringency of monitoring in order to increase the likelihood that violators are caught, along with increase penalties for doing so, including reduced promotion prospects. It can temporarily resolve the information asymmetry and misaligned incentives problems of the principal-agent framework. However, without continuous monitoring and permanent changes to the local cadre's performance evaluation system, it may be impossible to close the implementation gap at the local level.

How citizens express their environmental concerns and influence the policy design process of central leaders also fits the "principal-agent" framework, in which citizens are viewed as the principal demanding welfare benefits from central governments. In democratic settings, citizens can press for accountability to environmental laws through protests, voting, and litigation (Beierle, 2010; Kagan et al., 2003). In China, there are no formal mechanisms for civil society engagement, and individuals do not pick their leaders. For decades, the double-digit economic growth has kept criticism at bay. However, concerns and protests about environmental quality have increased in recent years. Environmental quality affects perceptions of Communist Party leadership in the eyes of China's citizenry. Chapter 4 studies the drivers of citizens' environmental concerns and asks how they might demand local environmental performance in an authoritarian setting.

1.2 Organizations of the thesis

The structure of this dissertation is as follows: Here, I briefly introduce my research questions, motivations for inquiry, and methodology used for Chapters 2 through 4.

Chapter 2 of my thesis examines the effectiveness of the central-initiated environmental inspections in bridging the implementation gap within a hierarchy. In contrast to the extensive attention on the effectiveness of formal policy levers in the literature (Greenstone and Hanna, 2014; Blackman et al., 2018; Tanaka, 2015), no study has examined the ability of top-down inspections to improve the effectiveness of environmental governance in hierarchies. Using the quasi-random timing of the environmental inspection, I show that inspections result in a sharp (approximately

34-39%) reduction in sulfur dioxide emissions near coal power plants during the month the inspection team is physically present.[2] Pollution reverts to prior levels after inspections end, and there is no long-term effect. The rate of reversion is faster for firms that outrank the municipal government, suggesting that a firm's accountability to the local environmental protection bureau is diminished by linkages to China's central authorities. Comparing the status of scrubber technology installments, I investigate the mechanisms by which plants alter pollution. During the inspection, plants with scrubbers showed larger reductions pollution compared to uncontrolled plants. After inspectors leave, the reversion to baseline is associated with a combination of lowering scrubber operation and increasing output. By temporarily increasing the stringency of monitoring and penalties associated with inadequate compliance of environmental regulations, central governments are able to hold local bureaucrats responsible for weak enforcement of environmental regulations. However, given that the inspection is a one-time shock and does not permanently change the incentive structure and information asymmetry in the "principal-agent" problem, the effect quickly attenuates once the inspection team leaves.

Chapter 3 of my thesis evaluates the effectiveness of a central-initiated effort to solicit citizen reporting on environmental problems. Previous research in the U.S. context suggests that concerned citizens may affect the behavior of polluters (Huet-Vaughn et al., 2018; Kagan et al., 2003). Evidence on the effectiveness of bottom-up monitoring programs in China is mixed and primarily qualitative (Hsu et al., 2020; Mertha, 2010). Using the quasi-random timing of citizen complaints in an event-study design and comparing firms receiving complaints to those that do not, I quantify the incremental effect of citizen complaints at the targeted power plant. Although citizen monitoring supposedly increases the monitoring capabilities of the state during crackdowns, I find that citizen complaints have no influence beyond the average round effect on coal power plant emissions. This is not surprising as central officials are physically present and conduct random spot-checks during the inspection period, which should largely resolve the information asymmetry problem.

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

Citizen reporting may not provide any additional information.[3] In Chapter 3, I also examine whether environmental inspections have the same impact in the lookback as they did in the original round. In general, power plants lower pollution less (and insignificantly) during the inspection and revert to pre-inspection levels after the inspection team leaves. But in the lookback round, where direct inspections of central SOEs are deployed, outranking firms revert more slowly. The incentive structure may need to be adjusted to ensure that outranking firms are faced with the same risks of punishment regardless of their ties to the central authorities.

Chapter 4 of my thesis identifies drivers of citizen engagement in the bottom-up monitoring program and how past contact with local bureaucrats influences future citizen participation in a dynamic setting. Exploring regional differences at the prefecture-city level, I discover city and plant characteristics that affect citizen participation. During environmental inspections, cities with low environmental performance at baseline receive more complaints per capita. However, citizens' complaints can not successfully pinpoint the dirtier polluters. Due to the knowledge-intensive nature of identifying pollution, if the central authorities wish to promote transparency and employ bottom-up monitoring as an information gathering tool, additional training and resources may need to be supplied to individuals to ensure accurate and appropriate reporting. In Chapter 4, I also test if citizens' participation in environmental monitoring programs is "path-dependent" (Gallagher, 2006; Croke et al., 2016). I ask if citizens' willingness to file complaints is dependent on the environmental effectiveness of the original round. Exploiting the natural experiment of the two rounds, I observe a decrease in air-related complaints received in the lookback round if measured air pollutants return to baseline levels after the original round concludes. This suggests the long-term effectiveness of the environmental protection program is necessary for the central government to be perceived as responsive to environmental concerns rasied by citizens. If the complaint channels cease to provide individuals with agency, the central government may not be able to reap the legitimacy benefits in the long run.

[3] Regression results in Chapter 4 indicate that citizens are unable to identify and report specific plants that polluted more during the baseline period, showing that the complaint channel is unable to provide accurate information on egregious polluters.

In Chapter 5, I synthesize the findings from previous chapters and propose policy suggestions.

Chapter 2

Crackdowns in Hierarchies: Evidence from China's Environmental Inspections

2.1 Introduction

Do short-lived increases in centralized regulatory enforcement improve the provision of public goods by industrial firms? Air pollution is a byproduct of industrial activity that harms human health and causes premature death (Cohen et al., 2017; Ebenstein et al., 2017). Despite a large and growing literature on the effectiveness of long-term environmental policies, such as five-year plans of China, in developing countries (Greenstone and Hanna, 2014; Blackman et al., 2018), we know very little about whether and how these top-down, intermittent enforcement crackdowns can improve performance.

Our study fills this gap by examining how coal power plants responded to rotating environmental inspections. Responding to increasingly severe episodes of poor air quality starting with the 2013 "Airpocalypse" (Beech, 2013), China's President Xi Jinping announced rotating crackdowns starting in 2016-2017 that directed central inspectors to scrutinize the efforts of provincial- and city-level environmental protection bureaus to detect and punish polluting firms over short (approximately one month) periods.

To quantify responses to crackdowns, we use high-frequency monitoring data on the ambient concentrations of a major short-lived industrial air pollutant, sulfur dioxide (SO_2). We focus on SO_2 because SO_2 is a short-lived major pollutant which can be largely attributed to stationary industrial sources.

We report two main findings. First, we find that during the one-month period while crackdowns are in progress, SO_2 pollution at monitors nearest to coal power plants falls on average by 35-39%.[1] However, within ten weeks after inspectors leave, reductions reduce by 50%. Pollution increases again though not to prior levels. Second, this reversion occurs fastest among plants accountable to the central government, the originator of the crackdowns, while cleanup persists longer among plants accountable to the local city government. The selection and timing of each crackdown round are used to identify effects on SO_2 pollution, as both are uncorrelated with a city's pre-crackdown SO_2 emissions trend. To improve comparability of the treatment and control groups within each inspection round, we employ entropy balancing (Hainmueller, 2012). We test for robustness of our results to alternative control groups. We present never-treated cities as our control group in the main paper, but include already-treated, and all plants in appendix. Results are robust regardless of what comparison group is used.

Our analysis is structured as follows. In Section 2.2, we reflect upon past literature and summarizes our contribution to the field. In Section 2.3 and 2.4, we describe our setting, data construction, and empirical approach. We present our main results on the magnitude and duration of crackdowns' effects in Section 2.5. Section 2.6 examines how plant linkages to different government levels affect responses. Section 2.7 examine mechanisms by which plants altered pollution during and after crackdowns. Section 2.8 concludes.

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

2.2 Literature review

2.2.1 Crackdowns: Definition and Prior Studies

We define a crackdown as a pre-announced increase in the stringency of regulatory scrutiny or enforcement (Eeckhout et al., 2010). 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, police brutality, polluting the environment, laundering money) that has exceeded an acceptable frequency, drawing attention and resources to reduce it. Crackdowns increase the 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 defines acceptable performance.

Prior work suggests that some crackdowns are effective at reducing targeted activities. Eeckhout et al. (2010) theorizes that random crackdowns deter violations at the margin by increasing likelihood of detection, and thus can be part of an economically optimal approach to monitoring. In other settings, crackdowns involve a one-time step up in scrutiny, as in the case of crackdowns on drug trafficking (Dell, 2015), money laundering (Johannesen and Zucman, 2012), or corruption in hospital procurement (Di Tella and Schargrodsky, 2003). Spatial (Dell, 2015; Johannesen and Zucman, 2012) and temporal (Di Tella and Schargrodsky, 2003) leakage of illicit activities has been shown to limit a crackdown's effectiveness. Our setting is different from crackdowns studied in the prior literature that involve only an increase in monitoring, as enforcement can be insufficient in our setting. For instance, Eeckhout et al. (2010) shows theoretically how intensifying monitoring for a subset of potential criminals is optimal in deterring crime. However, this analysis takes place entirely within the right column of the 2×2 table in Figure 2-1; enforcement is assumed to be perfect. In the extreme case where enforcement is zero, strengthening monitoring is predicted to have no effect; this presumably neutralizes its welfare-enhancing properties.

In all of prior studies, crackdowns involve state action against an agent (individual

Figure 2-1: Possible combinations of strong and weak monitoring and enforcement.

Monitoring		**Enforcement** Low	**Enforcement** High
	Weak	1	2
	Strong	3	4

or plant) directly, rather than via layers of a governing bureaucracy. Our setting allows us to examine a hierarchical setting, in which pressure originating with a principal (central government) is transmitted via a supervisor (local government) to an agent (coal power plant), similar to the three-layer hierarchy introduced in Tirole (1986). Our analysis takes place in a setting with two enforcement states: high and low shown in 2-1. The presence of the principal ensures enforcement of all violations (by lending clout to the supervisor). In the absence of the principal, enforcement is incomplete. A crackdown increases the likelihood that violations detected by the supervisor are punished, because the principal is looking over the supervisor's shoulder, ensuring punishment is meted out consistently. We consider high as the crackdown period and low is non-crackdown periods for a given locality. The crackdown may also increase monitoring, but importantly the role of monitoring is entirely dependent on the degree of enforcement.

We study a crackdown that is short-lived, originates at the apex of China's governing hierarchy, and ultimately affects all cities and polluting plants. While eventual treatment is assured, selection into rounds in random, timing is unpredictable, and plants can adjust in real time by changing production levels or running end-of-pipe control technologies. Our study contributes empirical evidence of how crackdowns work in authoritarian state-business hierarchies, adding to the literature on the economics of crackdowns (Di Tella and Schargrodsky, 2003; Dell, 2015; Johannesen and

Zucman, 2012; Eeckhout et al., 2010). Centrally-led crackdowns are a common approach to closing local enforcement gaps in China (Perry, 2019; Van Rooij, 2006). We find that during the one-month inspection period, China's environmental crackdowns result in large pollution reductions, comparable in magnitude to the reductions required by recently-implemented SO_2 emissions standards (Karplus et al., 2018). The observation that pollution reverts after inspectors leave suggests that the crackdown temporarily altered plants' cleanup incentives, rather than revealing poor performance or informing managers on how to improve.

2.2.2 Hierarchical structure and "central SOE problem"

We differentiate between a plant's accountability to the originator of the crackdown (the central government) and to its local agent (the city government). By studying plant responses to crackdowns, we can infer how pressure on plants changes as a function of central government scrutiny, 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 response patterns reveal the dynamic balancing of objectives at different levels of the government hierarchy.

Ensuring that local actions align with 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 government cadres to localities, often reaching over the intermediate layers of the bureaucracy, to advance population control, heath and sanitation, anticorruption, or environmental quality goals (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.

Observing plant response patterns allows us 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). Variation in power plant oversight by different levels of the government hierarchy allows us to conduct a large-N empirical test of a phenomenon described in the environmental politics literature on China as the "central state-owned enterprise (SOE) problem" (Eaton and Kostka, 2017). Here, the "problem" can be understood as local governments struggling to enforce regulations against SOEs accountable to central authorities in Beijing. We find that when central scrutiny is high during crackdowns, reductions are similar across plants. However, once the center withdraws its inspection team, plants accountable to the central government quickly return to prior polluting levels, while plants overseen by the city government revert more gradually. This pattern suggests that a local government's difficulty in deterring polluting actions by a plant that "outranks" them may be contributing to China's ongoing environmental problems.

2.3 Empirical Setting

2.3.1 China's rotating environmental inspections

China's Central Commission on Comprehensively Deepening Reforms proposed the creation of a "Central Environmental Inspection Team" in July 2015 (State Council, 2015). Inspection teams are overseen by the Ministry for Environmental Protection

(MEP)[2] and are patterned on teams that carried out a recent nationwide anticorruption crackdown (Xu, Hao, 2017). Inspection teams from the central government were deployed to cities, where they conduct month-long reviews of local governments' environmental protection efforts. The goal of the inspections was to ensure that all provincial-level regions follow the central government's direction when implementing pollution control measures.[3] For the coal power plants in our study sample, this involved monitoring plant compliance with emissions concentration standards and investigating citizen complaints. The crackdown consisted of five rounds of inspections, starting at the end of December 2015 (trial round, Hebei Province only) and ending in late 2017. During these two years, the inspection team covered all 31 provincial-level administrative regions in mainland China.[4]

While on site, inspectors scrutinized the activities of city environmental protection bureau staff and power plant managers. During their stay in a targeted province, the inspection teams reported lapses in compliance with central environmental requirements, oversaw 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 $135,000$ complaints, punished over $29,000$ companies, and imposed fines totaling 1.4 billion yuan (224 million US dollars) (People's Daily, 2017). A total of $1,527$ people were detained and almost $18,000$ officials were held accountable. Table 2.1 summarizes key statistics for the five inspection rounds, while the geographic distribution is shown in appendix Figure B-1. 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 announce plans to repeat inspections every few years.

[2] The Ministry of Environmental Protection was reorganized as the Ministry of Ecology and Environment (MEE) in mid-2018.

[3] We use the term "provinces" to refer to all provincial-level regions, including provinces, autonomous regions and municipalities.

[4] Environmental inspection teams were not dispatched to Taiwan or two special administrative regions (Hong Kong and Macau).

Table 2.1: 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 Conc	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. "Conc" is concentration. Data are from portals describing environmental inspections by province, which are available via the Ministry of Ecology and Environment's website (MEE, 2018). Data are available upon request.

2.3.2 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. The guidelines were distributed to local governments around August 2015 by the State Council before the official launch of the pilot program in Hebei province on December 2015.

An inspection round is divided into stages. First, members of the inspection team are selected anew in each round, primarily from two agencies: the national 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. Some inspection teams included journalists and provincial environmental protection bureau workers. Following selection, on-site inspection plans were shared with subordinate governments for the first time, no earlier than four weeks prior to arrival.

Next, the central team conducts an inspection in the targeted province(s) lasting four to five weeks. While locally based, the team conducts their own unannounced inspections of plants and sets up telephone hot lines, 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 the accuracy of a complaint is verified, a plant is typically 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 plants' regulatory violations. In addition to investigating public complaints, the inspection team also carries out random spot checks on polluters and conducts interviews with local bureau chiefs on the status of the implementation of environmental regulations. This includes but is not limited to officials from environmental, land, and resources bureaus, local CCP officials, and state-owned enterprise leaders.

After the inspection ends, teams evaluate the performance of the cities included in each round and submit their findings in a report to the provincial government. Reports evaluate local regulatory enforcement capabilities and describe areas needing improvement. Some of the common problems included: 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 are handed to the provinces, cities enter the "Rectification and enforcement" stage. Within 30 days, each city government is required to develop and submit a "rectification plan" to the State Council for approval. The plan must 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. After approval by the State Council, provincial leaders are required to publish the "rectification plan" and provide updates on its implementation status to the public.

2.3.3 Coal power plant responses

Coal power plants in China produce electricity for industrial and residential users, emitting SO_2 and other air pollutants as a byproduct. They are the dominant emitter of pollutants in China, comprising 92% of total SO_2 emissions and 72% of total CO_2 emissions. Plants face limits on the concentration of SO_2 emissions in their stack gases, which are defined by emission standards. Standards for SO_2 have become increasingly stringent since July 2014, when the standard GB13223-2011 went into effect (Karplus et al., 2018). Tougher "ultra-low emissions" standards were announced in September of 2014, requiring an additional 65% reduction in SO_2 concentrations relative to GB13223-2011 by 2020. While retrofits were underway, these standards were not binding during the period we study (2016-2017).

In addition to altering plant output, a manager has several options to control SO_2: (1) increase the use of low-sulfur coal, (2) adjust boiler efficiency, or (3) install and operate a pollution removal device. The third option has been the primary plant response to increased standard stringency since 2014 (Tang et al., 2019). Plants remove SO_2 pollution from waste gas streams using a technology installed on the plant's exhaust stack known as flue gas desulfurization, or a "scrubber." Historically, low rates of scrubber installation and operation have contributed to high air pollutant emissions in China (Xu, 2009). Operating a scrubber is costly: one estimate suggests operating costs are equivalent to a fourth of a generator's profit margin (Xu, 2011).

Electricity pricing reforms since 2015 have meant that coal power plants are likely to be more sensitive to the cost of scrubber operation. Historically, power plants in China were compensated based on annual generation quotas at prices set by the government. With reforms, an increasing share of a plant's production can now be sold outside of the quota via bilateral contracts or markets, typically at lower prices than electricity sold under annual quotas. Plants with scrubbers are entitled to sell their electricity at a premium, although it is unclear if scrubber operation is verified and if out-of-quota purchases receive these premiums.

2.4 Empirical methods

2.4.1 Data Construction

2.4.1.1 Timing of Environmental Inspections

To determine the start and end date of inspections, we rely on public announcements scraped from the MEP (now MEE) website,[5] and corroborate them with the dates reported by various media outlets.[6] As firms may have learned of an impending inspection during the two-month period between internal selection and arrival, we asked officials and plant operators in Hebei and Shandong how far in advance they were aware of the inspections. The earliest point at which any of our interviewees was aware of an inspection was one month ahead, although most were not informed until a few days in advance. We therefore define treatment as the beginning of the pre-inspection "Announce" period, four weeks prior to the inspectors' on-site arrival. This allows us 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.

[5]Detailed information on the timing of inspections can be accessed at (MEE, 2019).

[6]We compiled reports from multiple news outlets including *China Daily*, Sina news, and Wangyi 163 news.

2.4.1.2 SO_2 emissions

We focus on emissions of SO_2 for several reasons. SO_2 is a major pollutant and contributes to the formation of ambient particulate matter (PM). Both SO_2 and PM cause cardiovascular and respiratory disease in humans. 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. Moreover, SO_2, unlike NO_x, is largely not emitted from transportation sources. 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. Monitor-level data are available for all coal power plants before, during, and after crackdowns.

Data are assembled from the China National Environmental Monitoring Center's publicly-available data platform, which publishes hourly pollutant concentrations at all monitoring stations.[7] 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 monitor nearest each plant 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 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 eight provinces (two per round) for which data were available and complete: Heilongjiang, Henan, Hubei, Guangdong, Shanxi, Hunan, Zhejiang and Shandong. Our power plant sample is comprised of 1308 plants in 116 cities, and covers the four inspection rounds excluding the trial round. Our eight province data set contains 398 individual monitors.

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

2.4.2 Empirical approach: entropy balancing

We use the selection and timing of inspection waves to identify average effects of the crackdown on SO_2 pollution around targeted plants. In order to attribute changes to the central inspection team's arrival, the selection and timing of inspections must be uncorrelated with plants' environmental performance. This is plausible for two reasons. First, all provinces were inspected, regardless of environmental record, and timing was chosen for reasons unrelated to pollution patterns, such as maintaining regional diversity within each round and limiting predictability. 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 four weeks in advance, and response patterns are consistent with this assumption. As a result, even plants in regions included in the final round, which might have otherwise foreseen inspections, would not have been able to anticipate the timing. Plants in never-treated cities, defined as cities that were not included in all prior rounds, serve as within-round controls. Our econometric estimates therefore isolate the effect of being in a treated city relative to a control city after inspections begin within each round. Our results are robust to including all untreated and only already-treated cities in the control group.

Even if the selection of cities into rounds and the timing of inspections is plausibly exogenous, differences in the economic composition of cities may complicate comparisons between treatment and control plants. We examine predictors of a city's targeting in different rounds using linear probability and logit models (Appendix Table A.1) for cities in the 31-province sample. We find that per capita income predicts inclusion in the Trial Round and Round 4. Population density predicts inclusion in the Round 2. Total dust emissions predicts inclusion in the Trial Round, Round 2 and Round 3. Other covariates do not robustly predict inclusion in the treatment group. Importantly for identification of inspections' effects, SO_2 levels during the announcement or baseline periods do not predict inclusion in rounds. We perform a t-test to detect differences in a wide range of observable city and plant characteristics (per-capita income, population density, capital investment, electricity usage, dust emissions, SO_2 emissions, distance to city center, plant share of city business revenue, company age, state ownership) between treatment and control groups within each round. As shown in Appendix Table A.2, treatment and control groups are not balanced within rounds. We therefore implement a data preprocessing strategy, entropy balancing (Hainmueller, 2012), to generate a control group for treated plants by round that is balanced on observable characteristics.

Entropy balancing is implemented by calibrating each observation's weight to ensure re-weighted plants in treated cities and those in control cities are balanced on covariates.[8] We balance on the first-order covariates, 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, population density, capital investment, electricity usage, SO_2 emission and dust emission; and (ii) plant characteristics of geographical location, revenue share, company age, ownership and oversight level.[9] After entropy balancing, balance tests in Appendix Table A.3 show preexisting characteristics are not statistically different between treatment and control plants for the first two rounds, but are still significantly different for round 3. This is due to the fact that tolerance level for the entropy matching algorithm is set at a higher level. To check for parallel trends, we run event study regressions for the original and entropy-balanced samples. As shown in Appendix table A.4 and figure B-2, using plants in never-treated cities as control group, we see treated cities being significantly dirtier in the baseline week. We see reversed effect if we use plants in already-treated cities as control groups. We still observe parallel trends between treated and control groups and our results are robust to using all and already-treated cities as controls.

[8] 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`.

[9] Round 3 includes the provinces Shanxi and Hunan, which are less densely-populated and poorer than the six control provinces. For this round, the entropy balancing algorithm can not converge and tolerance level is set at 12 instead of 0.05.

2.5 Crackdown effects on SO_2 pollution

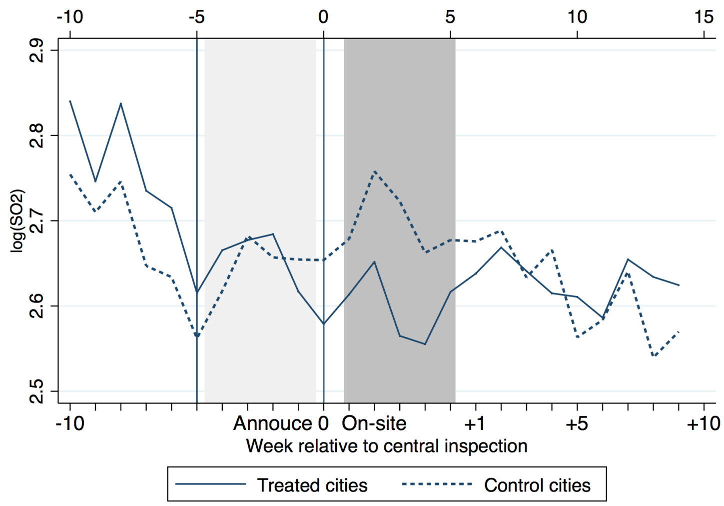
2.5.1 Visual Evidence

To examine how crackdowns affect SO_2 pollution, we begin by visually inspecting changes in raw measurements of ambient SO_2 in cities while inspectors are present. For this comparison, we make use of average SO_2 pollution levels for all cities in China. Figure 2-2 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 to the left of the 0th week corresponds to the four-week period between when inspections are announced and inspectors arrive on site. On average, treated cities (solid line) reduce their SO_2 emissions 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. The gap persists from the end of the announcement period until approximately eight weeks following the completion of on-site inspections as shown in Figure 2-2(a), and eventually treatment and control SO_2 levels converge, as shown in the longer post-period in Figure 2-2(b).[10]

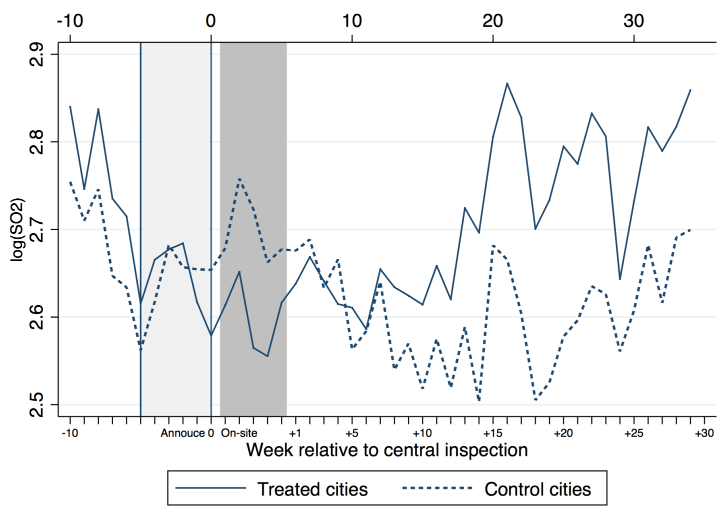
The remainder of our analysis focuses on observations of ambient SO_2 pollution at monitors nearest to power plants in our eight-province sample. The nationwide pattern in Figure 2-2 is replicated in Appendix Figure B-3 for the plants in the analysis sample. To evaluate how well monitor measures capture 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 (CEMS) installed on plant stacks for Henan province. CEMS measurements are available for very few plants at the start of inspections, so we use ambient monitor measures to ensure coverage of pre-period observations. Appendix Figure B-4 shows

[10] After 10 weeks, some control cities are included in the subsequent inspection round.

Figure 2-2: Comparison of SO_2 concentration in treated and control cities around the inspection event window.



(a) Short-term (up to 10 weeks post inspection)



(b) Long-term (up to 30 weeks post inspection)

Note: 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.

a strong correspondence between the nearest monitor and plant stack SO_2 measurements, suggesting our monitor measure is an acceptable proxy for direct emissions from power plants.

2.5.2 Quasi-experimental evidence

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

$$\ln(\text{SO}_{2it}) = \alpha + \delta(\text{Announce}_{it}) + \lambda(\text{Onsite}_{it}) + \xi(\text{Post}_{it}) + \gamma_i + \lambda_t + \epsilon_{it} \tag{2.1}$$

Here, the dependent variable is ambient pollution as reported by the monitor located nearest to each coal power plant in our eight-province sample. SO_{2it} is plant i's average SO_2 concentration ($\mu g/m^3$) in week t. To capture any effects of announcing the crackdown in advance of its official start date, Announce_{it} is set to 1 for observations recorded up to four weeks before the central inspection team arrives in inspected cities, and is otherwise zero. Onsite_{it} equals 1 during the inspection period (when the central inspection team is physically on site) in inspected cities, and is otherwise zero. Post_{it} equals 1 in the post period (after the central inspection team leaves the province) in inspected cities, and is otherwise zero. Changes in SO_2 before, during, and after to crackdowns are estimated in log points relative to the average baseline SO_2 pollution level (defined by the period between five and ten weeks prior to the inspection). Power plant fixed effects γ_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 λ_t to account 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 (such as the ongoing implementation of national SO_2 standards) over time that are common to all power plants. Standard errors are clustered at the city level.

Table 2.2 summarizes the estimated effects of inspections, with specifications that

Table 2.2: Average effects of the announcement, on-site, and post-inspection periods in the entropy-balanced and original samples.

	Original	EB	Original	EB
	(1) log(SO_2)	(2) log(SO_2)	(3) log(SO_2)	(4) log(SO_2)
Announcement	-0.119**	-0.168***	-0.119**	-0.169***
	(0.047)	(0.047)	(0.047)	(0.047)
On-site	-0.351***	-0.393***	-0.347***	-0.389***
	(0.056)	(0.062)	(0.056)	(0.063)
Post	-0.233***	-0.244***		
	(0.059)	(0.077)		
Post 1-5 wks			-0.315***	-0.281***
			(0.054)	(0.080)
Post 6-10 wks			-0.153**	-0.211**
			(0.068)	(0.083)
R-squared	0.742	0.711	0.742	0.711
Observations	75,885	57,696	75,885	57,696
# of plants	1308	1308	1308	1308
Plant FE	Yes	Yes	Yes	Yes
Year FE	Yes	Yes	Yes	Yes
Week FE	Yes	Yes	Yes	Yes

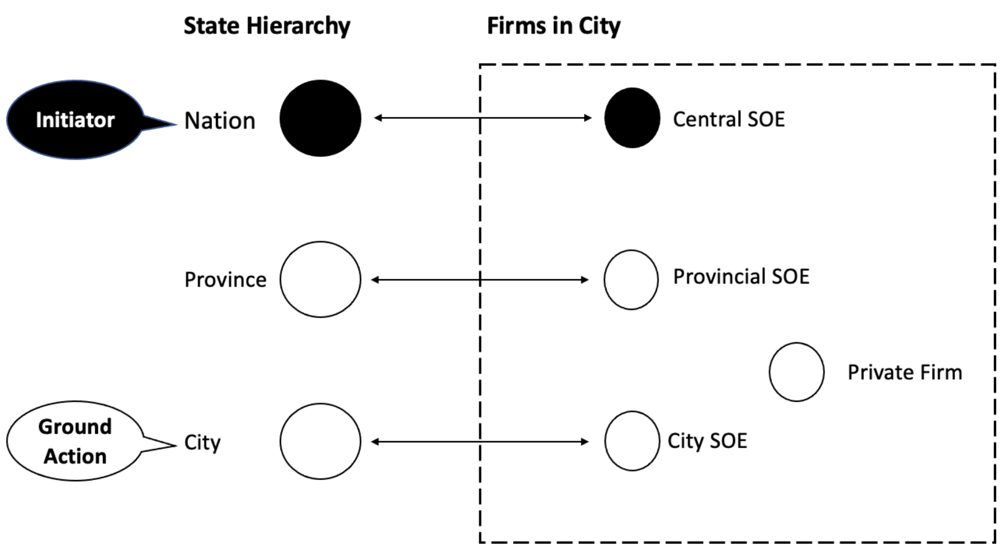
Notes: EB refers to estimates using the entropy-balanced sample. Baseline weeks (prior to the announcement period) are the omitted reference group. All specifications include plant, year, and week fixed effects. "Announce" refers to the announcement period, the earliest window during which a city would 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.

include two post-inspection horizons (1-5 and 6-10 weeks) for both the original and entropy balanced samples. When inspection teams are on-site, SO_2 levels at plants drop by 35-39% in log points. This is a substantial reduction in average ambient SO_2 concentration around plants, relative to baseline levels. The effect magnitude is slightly larger in the entropy-balanced sample, compared to the original sample. Results are robust to excluding the six plants that are permanently shut down following inspections. After the crackdown ends, reductions attenuate, falling to less than a half of on-site reduction levels by the second half of the ten-week post period.[11]

2.6 Government oversight and plant responses

We examine whether plants responses differ as a function of their accountability to the central versus the local state. State-owned enterprises (SOEs) in China are differentiated by their accountability to their respective levels of China's governing hierarchy, as shown in Figure 2-3.

Figure 2-3: Schematic of China's government hierarchy and linkages to industrial firms.



In China's power sector, 61% of installed coal capacity is majority state-owned (Hervé-Mignucci et al., 2015). We introduce heterogeneity by differentiating between central SOEs, which are accountable to the originator of the crackdown (the central government), and lower SOEs, which are accountable to the city government. City environmental protection bureaus have been found in prior work to face greater difficulty in enforcing regulations at plants that are not directly accountable to the city through oversight ties, a phenomenon known as the "central SOE problem" (Eaton

[11]While extending the post period suggests firms revert completely, in one case subsequent inspections are announced at 11 weeks into the post period, confounding the main effect of inspection.

and Kostka, 2017). I am 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.

Results in Table 2.3 show that while all plants reduce SO_2 emissions during crackdowns, central SOEs revert more quickly to prior levels than city SOEs after crackdowns end. During the on-site period, there is no significant difference between the reductions achieved by central SOEs relative to other plant types (see column (2) of Table 2.3). However, columns (4) and (5) show that central SOEs revert faster once the inspection team leaves, as indicated by the coefficient on the interaction between central SOE status and post-period, while local SOEs (the comparison group) show deeper reductions relative to baseline levels. We also compared provincial SOEs to lower SOEs and find similar results. There is no significant difference between the reversion speed of private firms and local SOEs.

2.7 Mechanisms

Our data further allow us to observe the mechanism(s) by which plants altered pollution during and after crackdowns. Over the short (multi-week) time frames we use to resolve effects of crackdowns, coal power plants faced limited options to reduce SO_2 emissions. One option was to operate an already-installed SO_2 emissions control device (or "SO_2 scrubber"). Approximately 80% of the plants in our sample had SO_2 scrubbers installed prior to the arrival of inspectors. 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 plants. A second option for plants to curb SO_2 emissions is to reduce output.[12] We assume plants pursue one or both of these options to alter SO_2

[12] Other reduction opportunities, such as switching to low-sulfur coal or installing a scrubber, are costly, harder to reverse, and, most importantly for our study, not possible to implement on a short (multi-week) time horizon. Most plants had already switched to low-sulfur coal by the period of our study (Tang et al., 2019).

Table 2.3: Effect of inspections interacted with a firm's central SOE status in the on-site and post-inspection periods. Comparison group is lower SOE

	(1) log(SO_2)	(2) log(SO_2)	(3) log(SO_2)	(4) log(SO_2)	(5) log(SO_2)
Announcement	-0.142**	-0.082	-0.141**	-0.140**	-0.141**
	(0.065)	(0.081)	(0.065)	(0.065)	(0.065)
On-site	-0.323***	-0.323***	-0.284***	-0.323***	-0.318***
	(0.076)	(0.076)	(0.088)	(0.076)	(0.076)
Post 1-5 wks	-0.249***	-0.249***	-0.249***	-0.340***	-0.246**
	(0.094)	(0.094)	(0.094)	(0.098)	(0.094)
Post 6-10 wks	-0.141	-0.141	-0.141	-0.140	-0.262***
	(0.092)	(0.092)	(0.092)	(0.092)	(0.089)
Announcement× Central SOE		-0.104			
		(0.066)			
On-site× Central SOE			-0.067		
			(0.061)		
Post 1-5 wks × Central SOE				0.155***	
				(0.053)	
Post 6-10 wks× Central SOE					0.215***
					(0.061)
R-squared	0.737	0.737	0.737	0.738	0.739
Observations	17,322	17,322	17,322	17,322	17,322
# of plants	390	390	390	390	390
Plant FE	Yes	Yes	Yes	Yes	Yes
Year FE	Yes	Yes	Yes	Yes	Yes
Week FE	Yes	Yes	Yes	Yes	Yes

Note: Uses the entropy balanced power plant sample. Sample is limited to only central and lower 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 Central 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.

emissions levels.

We find suggestive evidence that plants reduced pollution during inspections mainly by operating scrubbers, while reversion after inspectors left can be explained by a combination of reducing scrubber operation and increasing output. To examine the output response, we focus on plants' NO_x emissions, which form when nitrogen and oxygen react during combustion and thus scale with plant output. Here, we use the entropy-balanced sample but exclude plants that have NO_x scrubbers installed (253 plants) in order to ensure that observed changes are due only to adjustments in plant output, and not changes in the application of end-of-pipe NO_x removal. We find that average NO_x levels do not deviate from baseline while inspectors are on-site (see Table 2.4). After inspectors leave, output increases above baseline levels, by 8% during the latter half of the post period (6-10 weeks, see column (2)). This pattern is consistent with plants compensating for the cost of running scrubbers during on-site inspections. Operating scrubbers requires electricity, therefore plant output net of this additional load is reduced during inspections. Most power plants in China receive basic compensation according to annual production schedules. Shifting output to periods with lower environmental scrutiny is consistent with behavior observed in other settings in which managers perform according to quotas or deadlines that affect performance evaluation (Oyer, 1998, 2002).

We further find that plants with scrubbers show a statistically-significant increase in SO_2 emissions in the first five weeks after inspectors leave, compared to plants without scrubbers (see Table 2.5, column (1)), suggesting firms may be turning controls off to save costs. The magnitude of this increase among plants with scrubbers is comparable across all ownership types (columns (2) through (5)), although only statistically significant for private plants (column (5)). By contrast, we find that the post-inspection output response (again, proxied by changes NO_x emissions) varies by ownership, as shown in Appendix Table A.5: lower SOEs only are found to reduce output during the on-site period, and their output levels remain depressed during the early weeks of the post period (column (5)) while other ownership types increase production to 9-13% above baseline levels (columns (3), (4), and (6)) by 6-10 weeks after inspections end. Local SOEs are more likely to face higher costs of running scrubbers because of their smaller size and older vintages, which are more difficult to retrofit; however, size alone does not explain the patterns we observe (see Appendix

Table 2.4: Effects on NO_x at plants during the announcement, on-site, and post-inspection periods.

	All	All	Central SOE	Provincial SOE	Lower SOE	Private
	(1) log(NO_x)	(2) log(NO_x)	(3) log(NO_x)	(4) log(NO_x)	(5) log(NO_x)	(6) log(NO_x)
Announcement	-0.005	-0.005	-0.005	-0.015	-0.062	0.011
	(0.027)	(0.027)	(0.042)	(0.045)	(0.047)	(0.031)
On-site	-0.006	-0.003	-0.001	-0.005	-0.138*	0.032
	(0.040)	(0.039)	(0.047)	(0.061)	(0.076)	(0.042)
Post	0.039					
	(0.036)					
Post 1-5 wks		-0.003	-0.022	0.042	-0.108	0.002
		(0.039)	(0.064)	(0.060)	(0.067)	(0.037)
Post 6-10 wks		0.076**	0.093	0.122**	-0.015	0.069
		(0.037)	(0.062)	(0.054)	(0.045)	(0.043)
R-squared	0.795	0.795	0.745	0.791	0.822	0.803
Observations	45,599	45,599	4,120	7,230	7,536	25,668
# of plants	1055	1055	95	174	179	591
Plant FE	Yes	Yes	Yes	Yes	Yes	Yes
Year FE	Yes	Yes	Yes	Yes	Yes	Yes
Week FE	Yes	Yes	Yes	Yes	Yes	Yes

Note: 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.

Table A.6). Instead, the evidence is consistent with continued heightened scrutiny for plants with local oversight, while central SOEs quickly return to prior polluting behavior.

2.8 Conclusion

Our analysis examines crackdowns as a response to gaps in the performance of a governing bureaucracy. We find that China's environmental inspections achieve large pollution reductions (35-39%) that do not persist. In treated cities, SO_2 pollution falls sharply during crackdowns and then increases thereafter.[13] This reversion occurred

[13]When we examine the coefficients on the year fixed effects in Table 2.2, we find SO_2 concentrations gradually decreased between 2015 and 2018, likely due to longer-term efforts, such as the ultra-low emissions standards, to strengthen plant-level controls (Tang et al., 2019).

Table 2.5: Direct effect of campaign with interactions on scrubber technology in different post periods by plant oversight.

	All (1) log(SO_2)	Central SOE (2) log(SO_2)	Provincial SOE (3) log(SO_2)	Lower SOE (4) log(SO_2)	Private (5) log(SO_2)
Announcement	-0.184***	-0.205***	-0.242***	-0.166*	-0.157***
	(0.044)	(0.069)	(0.069)	(0.086)	(0.043)
On-site	-0.307***	-0.174	-0.352***	-0.259**	-0.324***
	(0.065)	(0.116)	(0.073)	(0.127)	(0.081)
Post 1-5 wks	-0.310***	-0.203	-0.322**	-0.308*	-0.346***
	(0.095)	(0.153)	(0.129)	(0.158)	(0.116)
Post 6-10 wks	-0.149	0.045	-0.092	-0.224	-0.173
	(0.094)	(0.184)	(0.122)	(0.137)	(0.107)
On-site× SO_2 Scrub	-0.130***	-0.209**	-0.131**	-0.136	-0.116**
	(0.037)	(0.096)	(0.063)	(0.083)	(0.051)
Post 1-5 wks× SO_2 Scrub	0.013	0.017	0.013	-0.077	0.026
	(0.053)	(0.109)	(0.120)	(0.102)	(0.065)
Post 6-10 wks× SO_2 Scrub	-0.123**	-0.153	-0.255*	-0.118	-0.117*
	(0.061)	(0.166)	(0.142)	(0.114)	(0.070)
Observations	56,397	8,032	9,484	9,224	28,560
R-squared	0.726	0.721	0.716	0.769	0.724
# of plants	1308	176	228	214	673
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. Column (2) includes only central SOE firms (state-owned enterprises with national-level or provincial-level oversight). Column (3) includes only upper SOE firms (state-owned enterprises with national-level or provincial-level oversight). Column (4) includes only firms that are lower SOE (state-owned enterprises with city-level or county-level oversight). Column (5) 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. 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.

despite the fact that emissions monitoring data are regularly transmitted to, and readily observable by, China's central Ministry of Ecology and Environment.

Compared to the prior literature, our findings point to several additional factors that influence the effectiveness of crackdowns. How the cost and reversibility of plant responses interact with a crackdowns' time horizon appear to be important determinants of whether the targeted behavior is deterred entirely or merely displaced in time or space. In Eeckhout et al. (2010), rotating crackdowns on speeding induced drivers to slow down, a response that did not incur high private (e.g., investment) costs. Duration and local expectations about the frequency of a crackdown's recurrence may interact with plant-level 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 plants employed short-term measures—turning scrubbers on, and (in the case of local SOEs) temporarily restricting electricity output—that were relatively easy and rewarding to reverse.

We further show that plant accountability to central versus local regulators affects SO_2 reduction patterns once an inspection ends. The fact that central SOE plants returned to prior polluting behavior earlier than local SOE plants may reflect an updating of managers' expectations about the enforcement capabilities of the remaining (local) authority. Managers of central SOEs may have been more certain that they could escape detection or punishment after inspectors left, while city environmental protection bureaus were capable of deferring a return to high pollution levels among local SOEs.

Our results may be indicative of a broader administrative challenge that Chinese city environmental protection bureaus face when controlling central SOEs operating in their jurisdictions. 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 SOEs (China Minmetals Corporation and China National

Chemical Corporation) in addition to the geographical targeting of the first round. Ongoing scrutiny of plants outside of inspection periods is possible with the MEE's extensive network of environmental monitors and continuous emissions monitoring systems, but requires a clear central mandate to be useful in enforcement efforts.

If inspections led to only short-lived reductions in pollution, 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 transcending multiple layers of the hierarchy to punish plants is administratively challenging and infringes on local authority. Launching centralized crackdowns may have legitimized intervention. Plants may have perceived crackdowns as a short-lived, one-time shock, 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 plant responses, an important area for future study.

Second, the center may have viewed crackdowns as a way to gather information on, and raise awareness of, the nature and extent of local environmental problems, in order to better direct scarce enforcement resources and public relations efforts. Soliciting citizen complaints on egregious polluters as part of the crackdowns may have helped the central government to accomplish this goal. We quantify the incremental effect of citizen complaints in Chapter 3.

Third, central authorities may have launched crackdowns to demonstrate effort while limiting the burden on the economy and (central) state. By publicly revealing regulatory lapses at the level of local governments and plants, inspection teams may have reinforced the perception that inadequate local government oversight was responsible for air quality lapses, directing scrutiny away from central authorities. This practice is akin to the sacking of local officials over their handling of food safety scandals, environmental accidents, or epidemics such as SARS or the COVID-19 coronavirus. The fact that plant pollution returned to pre-crackdown levels, despite central government access to ongoing pollution monitoring data, suggests that officials may be dynamically balancing the need to demonstrate environmental cleanup effort against competing objectives.

Chapter 3

Effects of citizen scrutiny on polluter behavior in China

3.1 Introduction

Under what conditions can authoritarian regimes successfully harness popular pressure to advance state objectives? This chapter explains why China's authoritarian leadership has engaged citizens in environmental oversight. Specifically, I explain the seemingly unlikely decision to involve citizens in reporting on firms' polluting behavior as part of an enforcement shock in an authoritarian context. China is an important case to study because it is markedly different from industrialized democracies in which citizens can press for accountability to environmental laws through protests, voting, and the court system. Most prior scholarship has focused on these settings. Prior work has shown that stakeholders can strongly influence firm behavior (Beierle, 2010; Kagan et al., 2003). In democratic settings, civil action has prompted firms to go "beyond compliance" (Gunningham et al., 2004). In contrast, formal and informal channels for bringing complaints against polluters are more limited in China and must be sanctioned by the state.

As economic growth continued to take a heavy environmental toll, so grew the perception that state leaders were responsible, prompting criticism among citizens.

In China, one has seen the rising popularity of community monitoring programs that empower citizens to hold local bureaucrats and service providers accountable, for example, the "Environmental Hotline Platform 12369" and the "Black and Smelly Waters Program". However, evidence of the effectiveness of such citizen participation programs is mixed (Kostka and Zhang, 2018; Shin, 2018; Wang, 2018). Building on Chapter 2 that quantify the SO_2 emission reduction due to increased central scrutiny during the environmental inspection. This chapter evaluates the incremental effectiveness of the complaint channel on plants' environmental performance.

I probe the effectiveness of citizens' reporting by asking: (1) do firms receiving complaints clean up more during inspections? (2) does a complaint, a subsequent order for rectification, or holding officials accountable for pollution associate with a greater reduction magnitude? (3) in a repeated-game version, does such a program hold the same effect as the original round on regulating polluter behaviors? During the inspection period, plants named within a city did not reduce pollution more relative to those not named. Disciplinary actions taken against complained plants produce positive results in curbing pollution. However, once the center withdraws, plants not directly accountable to the city government quickly return to prior polluting levels. I document the diminishing effects of central scrutiny on polluter behavior during the onsite and post period in the lookback round, suggesting plants learn and update their beliefs on the seriousness of the program. However, since direct oversight is put on central SOEs in the lookback round, outranking firms' pollution level remains lower than average even after the center leaves the locality. My findings suggest that the nature of citizen involvement, and its influence on firm environmental performance, is 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.

This chapter is structured as follows. Section 3.2 provides a brief review of relevant literature. Section 3.3 and 3.4 describes the difference between the two inspection rounds and how I build the complaint data set. Section 3.5 presents my main results on the incremental effect of citizen scrutiny and disciplinary actions. Section 3.6 examines if plant behavior changes in the lookback round. Section 3.7 reflects on the implications of my findings.

3.2 Literature Review

An important contribution of this study involves documenting a novel model of environmental governance in China, a hybrid approach combining top-down central crackdown and bottom-up local citizen engagement. I build on prior literature that describes how China's environmental governance has evolved over the past forty years, since the start of economic reform and opening in the late 1970s. China's central government has had air and water pollution regulations in place since the late 1980s; however, implementation was weak and uneven (Van Rooij, 2006). Until the end of the Tenth Five-Year Plan in 2005, researchers widely and repeatedly documented how economic goals superseded environmental goals. Strong protection of industry by local governments was found to thwart centrally-initiated environmental cleanup efforts (Kostka, 2014), while central state-owned enterprises' poor environmental records suggested they may have used state ties to weaken environmental scrutiny (Eaton and Kostka, 2017). As central leaders recognized the growing environmental toll of economic growth, regulations and enforcement grew more stringent. Environmental objectives were incorporated into government employee evaluations (Liang and Langbein, 2015).

Despite central government efforts to strengthen pollution control through national environmental regulations, they faced several challenges during local implementation. First, evidence suggests that as standards were codified or tightened, progress was exaggerated or falsified (Ghanem and Zhang, 2014; Chen et al., 2012). Holding local leaders responsible was found to bring about reductions in highly visible air pollutants but have little effect on water pollutants (Liang and Langbein, 2015). Second, tighter standards alone did little to address weak local implementation capacity. For example, monitoring equipment was not installed or operated on all plants according to MEP requirements (Steinfeld et al., 2009; Xu, 2011). Third, economic interest continued to complicate government progress on environmental cleanup at all levels of government. Local governments, facing the prospect of reduced local revenue streams, were perhaps the most resistant. Fourth, campaigns typically involved a period during which central state environmental scrutiny temporarily intensified before shifting focus to other priorities, with short-term action undermining the long-term effort. By the early 2010s, frequent episodes of severely degraded air suggested that China's prevailing model of environmental governance was facing dire limits.

The effectiveness of involving citizens in regulatory enforcement 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). In the United States, citizens joined together to take legal action against polluters, advancing the national environmental movement in the 1960s and 1970s. In Germany, the green movement, which has its roots in conservation societies and the organized protest of environmental destruction nearly a century earlier, has now been institutionalized in domestic politics (Rucht and Roose, 1999). Similar community monitoring programs that empower citizens to hold local bureaucrats and service provider accountable has been widely adopted in Chinese environmental governance, for example: "environmental hotline platform 12369" and "black and smelly waters program". However, evidence about the effectiveness of such citizen participation programs is mixed. Some find suggestive evidence of "rights consciousness" when citizens actively participate in such "naming and shaming" initiative to advance their own social justice issues (Hsu et al., 2020; Lorentzen and Scoggins, 2015; Mertha, 2010); Others points to the limitation of such initiatives due to low participation and lack of sanction (Kostka and Zhang, 2018; Shin, 2018). Some even further characterize it as a political gambit for the central government to manufacture "symbolic legitimacy" (Wang, 2018).

Engaging citizens might appear to be an unlikely feature of an authoritarian approach to environmental cleanup. Given this, why did the Chinese state establish a special 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 environmental violations and citizen discontent, expanding monitoring alongside enforcement. Second, it 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 signaled responsiveness and may have placated those most likely to complain. I examine to what extent a complaint directed at a plant translated into lasting environmental improvement.

In all, I describe a new model of environmental governance that emerged in China in response to a growing environmental crisis: a hybrid between the earlier campaign approach of targeting officials and a new approach involving enlisting citizens to identify pollution sources. Growing public outcry over the health effects of dangerously polluted air in the country's urban centers signaled a twofold crisis: it suggested increased recognition of systematic failures of the country's environmental governance mechanisms, while governance failures, in turn, attracted sharp criticism among ordinary citizens. In many respects, the hybrid approach I studied attempted to address both.

3.3 Empirical background

3.3.1 Timeline and difference of two inspection rounds

The original round of environmental inspections covered all 31 provincial-level regions in China and consisted of five batches, starting from the trial round in Hebei (December 2015) and ending in September 2017. The geographical distribution of the original round of inspection is shown in Appendix Figure B-1. Inspection teams were again dispatched in 2018 for a lookback (*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. The lookback round consists of two batches and covers 20 provincial-level regions. The geographical distribution of the lookback round is shown in Appendix Figure B-5. Table 3.1 compares key statistics for the two inspection rounds.

Table 3.1: Timeline and summary of two inspection rounds

	Original round					**Lookback round**	
	Batch 0	Batch 1	Batch 2	Batch 3	Batch 4	Batch 1	Batch 2
Start date	15/12/31	16/07/12	16/11/24	17/04/24	17/08/07	18/05/30	18/10/30
End date	16/02/14	16/08/19	16/12/30	17/05/28	17/09/15	18/07/07	18/12/6
Avg. GDP (billion)	3207	2577	3024	2139	2255	3191	2708
Avg. population (million)	63	41	37	36	32	48	46
Avg. per-capita GDP	51108	60725	85410	67145	60949	62469	56426
Pre-Inspec SO_2 Conc	42	26	17	29	18	26	27

Notes: In the original round, the trial batch, the pilot program, was launched in Hebei province. Batch 1 includes eight provincial-level regions: Inner Mongolia, Ningxia Hui, and Guangxi autonomous regions, as well as Heilongjiang, Jiangsu, Jiangxi, Henan, and Yunnan provinces. Batch 2 includes seven provincial-level regions: Beijing, Shanghai, and Chongqing municipalities, as well as Hubei, Guangdong, Shaanxi, and Gansu provinces. Batch 3 includes seven provincial-level regions: Tianjin municipality, as well as Shanxi, Liaoning, Anhui, Fujian, Hunan, and Guizhou provinces. Batch 4 includes eight provincial-level regions: Tibet, and Xinjiang Uygur autonomous regions, as well as Qinghai, Sichuan, Hainan, Shandong, Zhejiang, and Jilin provinces.
Look back round consists of two batches. Batch 1 includes ten provincial-level regions: Inner Mongolia, Ningxia Hui, and Guangxi autonomous regions, as well as Hebei, Heilongjiang, Jiangsu, Jiangxi, Henan, Yunnan, and Guangdong provinces. Batch 2 includes Shanxi, Jilin, Liaoning, Anhui, Hunan, Guizhou, Hubei, Sichuan, Shaanxi, and Gansu provinces.

One key difference between the original and lookback round is central governments' attention to central SOEs. Given it was reported in the first round that officials in Hunan Province were afraid of and unwilling to tackle environmental violations by central SOEs (Zhang, 2019). The central government decides to scrutinize upper SOEs directly on an ongoing basis and consistently punish violations. Indeed, it included a direct inspection of two central SOEs (China Minmetals Corporation and China National Chemical Corporation) in addition to the geographical targeting of the first round.

3.3.2 Magnitude of citizen complaints

As part of the environmental inspections, central government officials enlisted local citizens to help report on egregious polluters through telephone hotlines, mailboxes, and social media channels. Complaints are passed on to the city environmental protection bureau for verification and follow-up, while the central inspection team oversees the process. I collected public complaints about firms by scraping the text of electronic records from the provincial environmental protection bureau (PEPB) websites. Each entry includes a complete 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. I provide the text of a sample complaint for a coal power plant in Chinese and English in Appendix Table A.7. 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, I further summarize information on all complaints received, which is publicly posted on the MEP website[1]. 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 the left section of Table 3.2, on average, during the original round, each province received around $3,000$ complaints (a detailed summary by province is included in Appendix Table A.8). The smallest number of complaints filed was around 500 for Ningxia Hui autonomous region (a less populated and less developed province in Western China). In comparison, Sichuan had the largest at nearly $9,000$ complaints. The number of complaints increased with each subsequent inspection batch. During the lookback round, each province received, on average, around $3,700$ complaints. Compared to later batches of the original round, fewer complaints are investigated. I examine drivers of citizen complaints in Chapter 4,

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

which helps explain why I see a decrease in citizen participation in the lookback round. On average, fewer disciplinary actions are taken against firms and officials.

Table 3.2: Summary statistics for the five inspection rounds.

	Original round					**Lookback round**	
	Batch 0	Batch 1	Batch 2	Batch 3	Batch 4	Batch 1	Batch 2
Start date	15/12/31	16/07/12	16/11/24	17/04/24	17/08/07	18/05/30	18/10/30
End date	16/02/14	16/08/19	16/12/30	17/05/28	17/09/15	18/07/07	18/12/6
Complaints received	2856	1637	2233	4494	5005	3709	3768
Firms rectified	NA	NA	NA	3471	4654	2256	1224
Cases Filed	125	NA	901	1241	1351	571	299
Fine (million RMB)	NA	NA	NA	5238	6755	5106	2141
Persons detained	123	39	38	58	53	46	9
Persons interviewed	65	272	667	951	607	282	180
Officials held accountable	366	428	446	666	809	431	218

Notes: "NA" means that information is not available.

3.4 Composition of citizen complaints

To study the scope of complaints, I collected public complaints about firms by scraping the text of electronic records from the provincial environmental protection bureau (EPB) websites. My sample covers all cities in the 16 provinces inspected in both the original and lookback round. Four provinces (Inner Mongolia, Henan, Heilongjiang, and Jilin) are dropped because local EPBs provide only picture format or partial data. I distinguish among the most common pollution types people complain about, e.g., air or water pollution. Since local officials are required to investigate citizen complaints and report whether it is true or false based on their on-site interview, I compare ratios of corroborated and uncorroborated complaints. I further consider whether they are related to non-industrial facilities, e.g., an outdoor grill restaurant, or industrial facilities, e.g., power plants. Among complaints filed against industrial facilities, I identify industrial types that received most of the complaints.

3.4.1 Methodology

I conduct keyword classification on all complaints filed in Hubei provinces during the one-month inspection period. The keywords I used for classification are listed in Table 3.3. All the keywords are generated by manually reading through a random sample of collected complaints, and I acknowledge the possibility of misclassification due to an incomplete keyword sample.

Table 3.3: Keyword used for classify categories.

Category	Keyword used for classification
Industrial facility	公司，企业，厂
Power plant	发电，热电，电厂，电力
Cement	水泥
Chemical refinery	化工，石油，石化
Iron & steel	钢铁，烧结，球团
Solid waste	垃圾焚烧，环保资源，绿色，生物质，能源，环保电力，环保科技
Non-ferrous metal	有色，金属，矿
Air	废气，气体，臭气，毒气，空气，气味，烟尘，粉尘，油烟，灰尘，异味
Water	废水，污水，排入
Noise	噪声，噪音

3.4.2 Breakdown of complaints by pollutant types

To examine the role of citizen scrutiny, I first investigate the extent of participation in environmental citizen-monitoring programs and identify key environmental interests of citizens (differentiating between air, water, noise, ecology, and other pollution categories). Table 3.4 presents the result of the complaints breakdown across different pollutant types. The most common type of complaint concerns air pollution. This suggests that the public responds most strongly to highly visible degraded air. I also see a great deal of noise complaints, based on raw complaint text, usually due to ongoing construction activity in the vicinity. The composition of citizen complaints is consistent across rounds. Compared with the original round, there is an increase in the ratio of soil and ecology-related complaints in the look back round, with a decrease in air-related complaints.

Table 3.4: Ratio of complaints by pollutant categories across rounds

	Air	Water	Soil	Noise	Ecology	Other
Original round:						
Mean	0.66	0.42	0.27	0.26	0.24	0.19
Median	0.67	0.43	0.27	0.24	0.23	0.14
Std Dev	0.09	0.11	0.12	0.09	0.12	0.13
Total number	299	299	299	299	299	299
Look back round:						
Mean	0.62	0.35	0.40	0.28	0.30	0.20
Median	0.64	0.35	0.40	0.27	0.30	0.19
Std Dev	0.16	0.13	0.15	0.11	0.14	0.10
Total number	252	252	252	252	252	252

Notes: City-level data are used. Ratios are defined as the number of complaints in one category divided by the total number of complaints for each city. Total complaints are defined as the average number of all complaints received within a city across each round. In original round, I combine category “dust” and “smoke” into category “air” and category “garbage” into ”soil” to provide consistency between the categorization in two rounds. Summary statistics are calculated from the raw data, without accounting for geographical or seasonal trends.

I further examine whether the majority of citizen complaints are corroborated or partially corroborated by local environmental authorities who conduct on-site interviews. Table 3.5 suggest only around 15% of complaints are classified as uncorroborated after local authorities’ investigation. Uncorroborated cases may result from false reporting or immediate clean-up actions taken by the polluters before the official’s visit. Compared to the original round, there is a decrease in the share of corroborated complaints in the lookback round.

These results are consistent in the detailed summary of complaint breakdown by provinces shown in Table 3.6 (original round) and Table 3.7 (lookback round). The “Other” column includes complaints against all but the named pollutant types, e.g., soil, ecology, and radioactive pollution. On average, around $60-70\%$ of complaints are filed against air pollution in all provinces in the original round. Provinces with inadequate water resources, e.g., Shanxi, Shaanxi, and Henan, receive fewer water-related complaints. Compared with the original round, there is also a decrease in the

Table 3.5: Ratio of complaints by un/corroborated across rounds

	Corroborated	Partial_corroborated	Uncorroborated
Original round:			
Mean	0.54	0.31	0.15
Median	0.50	0.29	0.11
Std Dev	0.30	0.28	0.16
Total number	299	299	299
Look back round:			
Mean	0.53	0.28	0.17
Median	0.56	0.00	0.13
Std Dev	0.34	0.33	0.15
Total number	252	252	252

Notes: City-level data are used. "Corroborated" corresponds to complaints classified as "True" in the original data and "uncorroborated" corresponds to complaints classified as "false" in the original complaint data.

Table 3.6: Complaints breakdown of industrial/non-industrial facilities and pollution type in original round

Province	Total	Industrial	Non-industrial	Air	Water	Noise	Other
Total	50475	0.67	0.33	0.67	0.39	0.29	0.2
Sichuan	7176	0.68	0.32	0.64	0.43	0.44	0.24
Anhui	3532	0.66	0.34	0.68	0.37	0.3	0.35
Shandong	8162	0.67	0.33	0.72	0.4	0.27	0.38
Shanxi	3631	0.58	0.42	0.7	0.2	0.2	0.08
Guangdong	3967	0.71	0.29	0.69	0.4	0.27	0.06
Guangxi	428	0.61	0.39	0.52	0.49	0.17	0.05
Jiangsu	2074	0.8	0.2	0.68	0.48	0.2	0.08
Henan	1224	0.48	0.52	0.65	0.25	0.28	0.07
Zhejiang	6959	0.78	0.22	0.75	0.49	0.27	0.22
Hubei	1950	0.68	0.32	0.62	0.38	0.27	0.06
Hunan	4482	0.57	0.43	0.6	0.36	0.31	0.14
Guizhou	3470	0.63	0.37	0.54	0.37	0.35	0.21
Liaoning	2635	0.65	0.35	0.64	0.33	0.23	0.17
Shaanxi	785	0.67	0.33	0.61	0.27	0.27	0.05

Notes: The complaints breakdown ratio does not necessarily add up to one. This is because some complaint entries may involve multiple firms and pollution types.

Table 3.7: Complaints breakdown of industrial/non-industrial and pollution type in look-back round

Province	Total	Industrial	Non-industrial	Air	Water	Noise	Other
Total	51336	0.63	0.37	0.64	0.34	0.3	0.19
Yunnan	1999	0.67	0.33	0.52	0.29	0.31	0.21
Sichuan	3560	0.76	0.24	0.64	0.4	0.46	0.29
Ningxia	1678	0.72	0.28	0.75	0.28	0.32	0.14
Anhui	2544	0.73	0.27	0.7	0.35	0.34	0.27
Shandong	4888	0.76	0.24	0.73	0.36	0.33	0.21
Shanxi	2588	0.63	0.37	0.6	0.2	0.22	0.21
Guangdong	6082	0.63	0.37	0.65	0.41	0.28	0.18
Guangxi	4612	0.57	0.43	0.65	0.45	0.27	0.18
Jiangsu	2275	0.79	0.21	0.71	0.47	0.33	0.28
Jiangxi	2577	0.72	0.28	0.71	0.49	0.2	0.15
Hebei	4114	0.53	0.47	0.58	0.16	0.17	0.08
Hubei	2582	0.75	0.25	0.65	0.33	0.27	0.05
Hunan	3766	0.65	0.35	0.63	0.35	0.35	0.13
Guizhou	2688	0.66	0.34	0.58	0.28	0.39	0.2
Liaoning	3922	0.66	0.34	0.57	0.27	0.25	0.2
Shaanxi	1461	0.65	0.35	0.67	0.27	0.27	0.24

Notes: The complaints breakdown ratio does not necessarily add up to one. This is because some complaint entries may involve multiple firms and pollution types.

share of air-related complaints in general. Citizens are more likely to report industrial facilities than non-industrial ones, which is not surprising as industrial facilities tend to be heavier polluters. However, I also see a large number of non-industrial facilities being reported. Besides Guangdong, Jiangsu, and Zhejiang provinces (which have a higher concentration of industrial activities), on average, around 65% of complaints are against industrial facilities. Compared with the original round, Table 3.7 suggests a decrease in the percentage of complaints filed against industrial facilities.

3.4.3 Breakdown of industrial complaints by plant types

Limiting complaints to those filed against industrial facilities, I further break down the complaints across industries. Table 3.8 shows the complaints received for different plant types in the original round. The "Other" column includes complaints against all but the named industries, e.g., the glassmaking, plastics, and dye industries. Complaints spread broadly across different polluting industries. The majority of complaints are filed against power plants (35%), chemical refineries (10%), and non-ferrous metals (20%). Surprisingly, only around 2% of the complaints are filed against the iron and steel industries.

Table 3.8: Industrial-facility complaints breakdown of industry in original round

City	Industrial facility	Power plant	Cement	Chemical refinery	Iron steel	Non-ferrous metal	Waste	Other
Total	33865	0.37	0.06	0.11	0.02	0.17	0.09	0.1
Sichuan	4870	0.54	0.06	0.11	0.01	0.13	0.1	0.13
Anhui	2321	0.34	0.08	0.08	0.03	0.18	0.08	0.09
Shandong	5492	0.36	0.06	0.16	0.01	0.15	0.08	0.12
Shanxi	2105	0.28	0.06	0.09	0.03	0.29	0.09	0.05
Guangdong	2834	0.4	0.04	0.07	0.02	0.13	0.06	0.08
Guangxi	262	0.29	0.06	0.03	0	0.2	0.08	0.08
Jiangsu	1654	0.39	0.05	0.24	0.02	0.11	0.1	0.1
Henan	585	0.14	0.05	0.17	0.01	0.06	0.02	0
Zhejiang	5435	0.35	0.06	0.08	0.01	0.12	0.1	0.1
Hubei	1323	0.33	0.09	0.14	0.02	0.17	0.1	0.09
Hunan	2569	0.35	0.07	0.07	0.01	0.23	0.09	0.1
Guizhou	2172	0.33	0.07	0.06	0.01	0.24	0.08	0.1
Liaoning	1718	0.25	0.08	0.12	0.04	0.27	0.06	0.08
Shaanxi	525	0.36	0.06	0.11	0.02	0.17	0.1	0.07

Notes: The complaints breakdown ratio does not necessarily add up to one. This is because some complaint entries may involve multiple firms.

Compared with the original round, Table 3.9 suggests there is a decrease in the percentage of complaints filed against power plants and chemical refineries.

Table 3.9: Industrial-facility complaints breakdown of industry in look-back round

City	Industrial facility	Power plant	Cement	Chemical refinery	Iron steel	Non-ferrous metal	Waste	Other
Total	34419	0.3	0.06	0.1	0.02	0.2	0.09	0.11
Yunnan	1342	0.3	0.05	0.09	0.02	0.29	0.11	0.12
Sichuan	2709	0.43	0.06	0.08	0.01	0.13	0.12	0.16
Ningxia	1205	0.28	0.08	0.1	0.01	0.2	0.1	0.1
Anhui	1846	0.27	0.07	0.09	0.03	0.19	0.1	0.09
Shandong	3705	0.28	0.06	0.15	0.02	0.17	0.09	0.11
Shanxi	1618	0.27	0.04	0.06	0.04	0.28	0.06	0.06
Guangdong	3850	0.44	0.05	0.1	0.02	0.12	0.11	0.17
Guangxi	2640	0.29	0.08	0.04	0.02	0.31	0.06	0.15
Jiangsu	1802	0.32	0.05	0.16	0.02	0.12	0.1	0.1
Jiangxi	1846	0.33	0.06	0.08	0.01	0.25	0.13	0.14
Hebei	2173	0.24	0.04	0.11	0.02	0.11	0.04	0.06
Hubei	1936	0.24	0.07	0.2	0.01	0.17	0.09	0.07
Hunan	2439	0.21	0.08	0.05	0.01	0.19	0.06	0.09
Guizhou	1786	0.23	0.06	0.05	0.01	0.24	0.07	0.08
Liaoning	2571	0.27	0.05	0.09	0.05	0.31	0.07	0.08
Shaanxi	951	0.27	0.1	0.1	0.01	0.2	0.09	0.09

Notes: The complaints breakdown ratio does not necessarily add up to one. This is because some complaint entries may involve multiple firms.

3.5 Environmental impact of citizen scrutiny

Because citizens remain once inspectors leave, complaints could prolong the firm's attention to reducing pollution. To understand whether involving citizens increased and extended the impact of inspections, I 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 bureaus, 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: the problem could be rectified, the firm could be shut down, and local environmental protection bureau officials could be held accountable. All complaints were investigated, and while the local environmental protection bureau did not corroborate some, many others resulted in corrective actions against firms during the crackdown. Among the firms that received complaints, a subset was either rectified, shut down, or officials were held accountable (summarized by ownership in Table 3.10).

Table 3.10: Outcomes of citizen complaints by ownership and oversight-level

	Complaint	Rectified	Shutdown	Officials accountable
Central SOE	69 (39%)	33 (48%)	1 (1%)	7 (10%)
Provincial SOE	80 (35%)	49 (61%)	2 (3%)	11 (14%)
Local SOE	74 (35%)	37 (50%)	1 (%)	5 (7%)
Private	219 (33%)	130 (59%)	11 (%)	21 (10%)

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).

I examine the effectiveness of allowing citizens to complain about polluting firms, focusing on three questions. First, I ask how do any SO_2 reductions differ at firms receiving complaints compared to the average plant in a city? Among firms receiving complaints, does disciplinary action have additional impacts on regulating firm behaviors? Second, I examine the effect of direct central scrutiny on "outranking" firms as inspection teams are dispatched directly to central SOEs in addition to the geographical targeting of the original round. I ask if environmental inspection effects persist longer for "outranking" firms than those plants directly accountable to local government. Using the same governing hierarchy structure shown in Figure 2-3, I 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. Third, I ask if the same effects hold in the lookback round as polluters update their beliefs on the seriousness of the central-initiated citizen monitoring program. I examine each of these questions in turn.

3.5.1 Incremental effect of citizen complaints

To examine the effect of receiving a complaint, I plot the distribution of plant's average pollution in the announce, onsite, and post crackdown periods, differentiated by complaint status, shown in Figure 3-1.[2] The narrowing of the distribution of SO_2 emissions, and in particular the elimination of the right tail, suggests that the dirtiest plants cleaned up the most in response to complaints, resulting in a reduction (leftward shift) in average SO_2 pollution at the mean. There is virtually no difference between the distribution of SO_2 pollution for plants that do and do not receive a complaint.

To estimate the impact of citizen engagement coupled with the inspection on plant-level SO_2 emissions, I estimate the following regression:

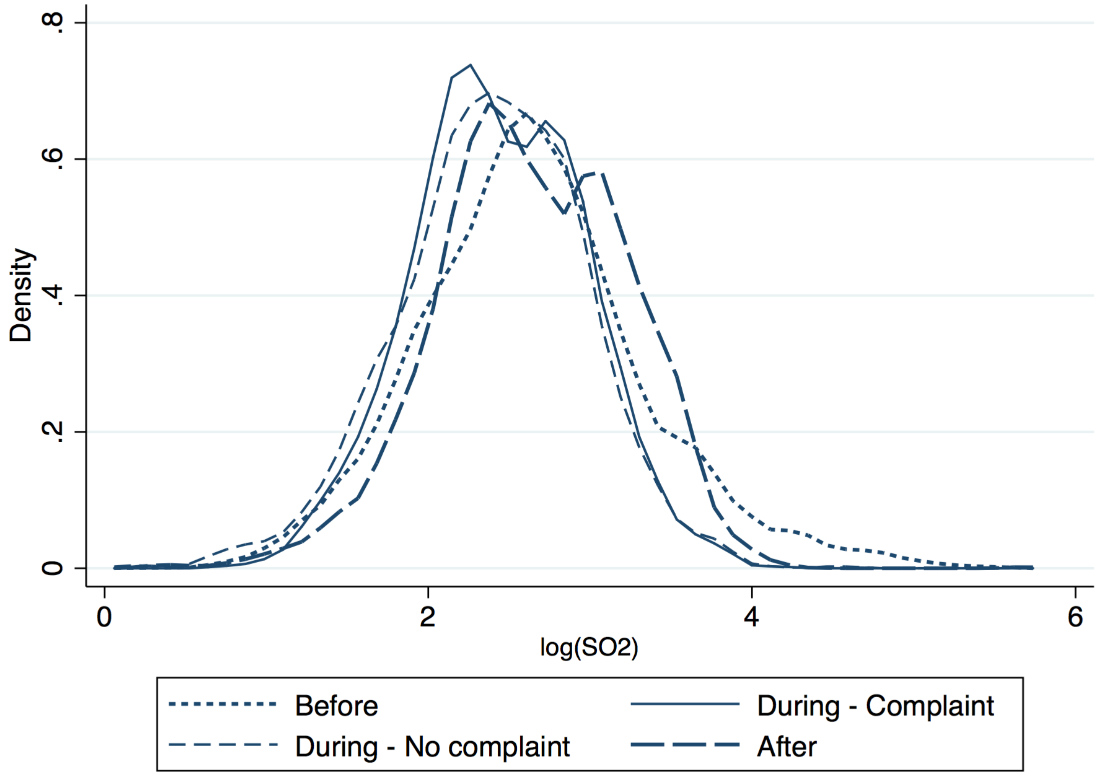
$$\ln(\mathrm{SO}_{2it}) = \alpha + \delta_1(\mathrm{Announce}_{it}) + \lambda_1(\mathrm{Onsite}_{it}) + \xi_1(\mathrm{Post}_{it}) + \\ \delta_2(\mathrm{Announce}_{it}) \times \mathrm{Action}_i + \lambda_2(\mathrm{Onsite}_{it}) \times \mathrm{Action}_i + \xi_2(\mathrm{Post}_{it}) \times \mathrm{Action}_i + \gamma_i + \lambda_t + \epsilon_{it} \tag{3.1}$$

Here, my dependent variable is the ambient pollution level reported by the monitor nearest each coal power plant in the eight-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 four weeks before the central inspection team arrives and is otherwise zero. Onsite_{it} equals 1 during the inspection period (when the central inspection team is physically on site) and is otherwise zero. Post_{it} equals 1 in the post period (1- 10 weeks after the central inspection team leaves the province) and is otherwise zero. Action_i corresponds to the complaint status or punishments taken against egregious polluters.[3] Changes in

[2]The same SO_2 emission data set in Chapter 2 is used to study the incremental environmental effect of complaints against thermal power plants.

[3]When examining the partial effect of receiving a complaint, I use the eight-province sample and Action_i equals 1 for plants that received a complaint. When examining the partial effect of punishment against complained firms, I limit my sample to plants that received a complaint during the inspection period. And Action_i equals 1 for plants required for rectification, being shut down, or officials in the overseeing local environmental protections bureau are held accountable.

Figure 3-1: Distribution of power plant SO_2 emissions concentration in treated cities



Note: Power plant SO_2 emissions is measured as ambient concentration ($\mu g/m^3$) at the level of individual monitors nearest to plants in the eight-province sample before, during, and after (10 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).

SO_2 in each phase are expressed in log points and relative to the average baseline period level (5-10 weeks prior to inspection). Power plant fixed effects γ_i control for time-invariant differences in SO_2 pollution around plants, due for instance to local geography, climatic conditions, or electricity demand. I include year and week controls λ_t for SO_2 concentration changes over time (e.g., due to seasonality of demand and weather) that are common to all power plants. In all regressions, standard errors are clustered at the city level, given that the shock is directed at the city government and its environmental protection bureau, which oversees regulatory implementation at local firms.

Table 3.11 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. When inspection teams are onsite, SO_2 levels at plants drop by 27% in log points. This is a substantial reduction in average ambient SO_2, relative to baseline levels. After the inspection team leaves the locality, reductions gradually attenuate. Complained plants show no difference in their responses to the inspections during the announcement, onsite, and post period. Differentiating between upper and lower SOEs reveals significantly higher reductions among the upper SOEs, suggesting the local government may find it difficult to enforce regulations at a firm that "outranks" them. This is consistent with Chapter 2 finding that rank matters.

3.5.2 Incremental effect of disciplinary actions

Beyond examining the partial effect of a complaint on a plant's response to the inspection, my data set allows me to go one step further and examine whether rectification, shutdown, or holding officials accountable has a lasting effect on polluting behavior. Focusing on rectification (Table 3.12), I find that rectified plants show no difference in their responses during the onsite period. During the post period, complained plants required for rectification reduce SO_2 more on average compared to those that do not. However, the results are not statistically significant. Differentiating upper state firms from the rest of the sample yields point estimates that suggest these outranking firms revert more quickly than average to prior polluting behavior (11% additional reversion in log points, significant at the 5% level), while all other firms remain below average. This is consistent with Chapter 2 finding that rank matters.

Shutdown produces similar results at a higher magnitude (Table 3.13). During the onsite and post period, complained plants temporarily shut down are not statistically different in SO_2 emission reduction from those that do not. Upper state firms again revert more quickly to baseline pollution level (38.2% addition compared to other firms, which remain below average, significant at the 5% level).

Further, I ask whether holding local officials accountable affected firm responses. In some cases, an investigated complaint revealed negligence on the part of a local

Table 3.11: Effect of inspections with interactions on plants receiving a complaint in the original round.

	(1) log(SO_2)	(2) log(SO_2)	(3) log(SO_2)	(4) log(SO_2)
Announcement	-0.096**	-0.096**	-0.096**	-0.096**
	(0.040)	(0.042)	(0.042)	(0.042)
On-site	-0.272***	-0.272***	-0.272***	-0.272***
	(0.034)	(0.035)	(0.034)	(0.034)
Post	-0.106***	-0.106***	-0.116***	-0.117***
	(0.032)	(0.032)	(0.035)	(0.035)
Announcement × Complaint	0.001			
	(0.021)			
On-site × Complaint		0.001		
		(0.021)		
Post × Complaint			0.029	-0.001
			(0.029)	(0.030)
Post × Complaint × Upper SOE				0.091*
				(0.046)
Observations	93,074	93,074	93,074	93,074
R-squared	0.696	0.696	0.697	0.697
Number of plants	1308	1308	1308	1308
Plant FE	Yes	Yes	Yes	Yes
Year FE	Yes	Yes	Yes	Yes
Week FE	Yes	Yes	Yes	Yes

Notes: Sample used in this table only spans to "Post 0-9 wks", that is until 10 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. 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.

environmental protection bureau official. As shown in Table 3.14, plants whose behavior was connected with negligence by officials showed non-significant larger drops during the onsite period. However, these plants revert to baseline levels and even increase SO_2 above baseline during the post period (16.1% addition in log points, significant at the 5% level). Differentiating upper state firms from the rest of the sample yields point estimates that suggest average plants revert to baseline levels more quickly while outranking firms stay below.

Table 3.12: Direct effect of the inspections with interactions on plants requiring rectification in the original round.

	(1) $\log(SO_2)$	(2) $\log(SO_2)$	(3) $\log(SO_2)$	(4) $\log(SO_2)$
Announce	-0.114**	-0.086	-0.087	-0.087
	(0.055)	(0.058)	(0.058)	(0.057)
On-site	-0.259***	-0.261***	-0.260***	-0.260***
	(0.046)	(0.047)	(0.045)	(0.045)
Post	-0.061*	-0.062*	-0.036	-0.038
	(0.033)	(0.033)	(0.039)	(0.039)
Announce × Rectified	0.050			
	(0.043)			
On-site× Rectified		0.003		
		(0.030)		
Post× Rectified			-0.047	-0.084*
			(0.038)	(0.043)
Post× Rectified× Upper SOE				0.110*
				(0.057)
Observations	34,051	34,051	34,051	34,051
R-squared	0.681	0.681	0.681	0.681
Number of plants	446	446	446	446
Plant FE	Yes	Yes	Yes	Yes
Year FE	Yes	Yes	Yes	Yes
Week FE	Yes	Yes	Yes	Yes

Notes: Sample used in this table are limited to plants received a complaint during the inspection period. 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.

3.6 Impacts of environmental inspection in the look-back round

In 2018, central inspection teams were again dispatched for a “look back” round to evaluate progress in addressing violations discovered in the first round. In this section, I examine the effectiveness of central inspection and citizen complaints in the lookback round compared to the original round. I ask as local polluters realize the “actual” seriousness of central’s desire to clean-up, will their behavior change? Another key difference between the original and lookback round is central governments’ attention

Table 3.13: Direct effect of the inspections with interactions on plants being shutdown in the original round.

	(1) $\log(SO_2)$	(2) $\log(SO_2)$	(3) $\log(SO_2)$	(4) $\log(SO_2)$
Announce	-0.090	-0.086	-0.086	-0.086
	(0.057)	(0.058)	(0.058)	(0.058)
On-site	-0.259***	-0.260***	-0.259***	-0.259***
	(0.045)	(0.046)	(0.045)	(0.046)
Post	-0.062*	-0.062*	-0.059*	-0.060*
	(0.033)	(0.033)	(0.034)	(0.034)
Announce × Shutdown	0.099			
	(0.139)			
On-site × Shutdown		0.009		
		(0.049)		
Post× Shutdown			-0.069	-0.133***
			(0.066)	(0.049)
Post× Shutdown× Upper SOE				0.382***
				(0.092)
Observations	34,051	34,051	34,051	34,051
R-squared	0.681	0.681	0.681	0.681
Number of plants	446	446	446	446
Plant FE	Yes	Yes	Yes	Yes
Year FE	Yes	Yes	Yes	Yes
Week FE	Yes	Yes	Yes	Yes

Notes: Sample used in this table are limited to plants received a complaint during the inspection period.

to outranking firms as inspection teams are dispatched directly to central SOEs during the lookback round. I further ask does direct central attention to outranking firms help prolong the environmental inspection effect? Can ongoing scrutiny of upper SOEs help resolve the "central SOE problem" identified in Chapter 2?

3.6.1 Effect of central inspection

To quantify the impact of an inspection on plant-level SO_2 emissions in the lookback round, I run the same difference-in-differences (DID) regressions in Table 2.2. Entropy balancing is again used to ensure treated and control groups are balanced within rounds.

Table 3.14: Direct effect of the inspections with interactions on plants with officials accountable in the original round.

	(1) $\log(SO_2)$	(2) $\log(SO_2)$	(3) $\log(SO_2)$	(4) $\log(SO_2)$
Announce	-0.085	-0.086	-0.087	-0.087
	(0.111)	(0.106)	(0.106)	(0.106)
On-site	-0.259***	-0.248***	-0.261***	-0.260***
	(0.056)	(0.060)	(0.056)	(0.056)
Post	-0.061	-0.061	-0.078	-0.078
	(0.052)	(0.052)	(0.056)	(0.056)
Announce × Officials accountable	-0.013			
	(0.044)			
On-site× Officials accountable		-0.092		
		(0.082)		
Post× Officials accountable			0.134	0.161*
			(0.072)	(0.071)
Post × Officials accountable × Upper SOE				-0.065
				(0.059)
Observations	34,051	34,051	34,051	34,051
R-squared	0.681	0.681	0.681	0.681
Number of plants	446	446	446	446
Plant FE	Yes	Yes	Yes	Yes
Year FE	Yes	Yes	Yes	Yes
Week FE	Yes	Yes	Yes	Yes

Notes: Sample used in this table are limited to plants received a complaint during the inspection period.

Table 3.15 summarizes the estimated effects of inspections on coal power plant emissions during the lookback round. Compared to the original round, pollution drops less when the inspection teams are onsite and is not statistically significant. During the lookback round, while inspection teams are on site, SO_2 only drops by 3.2-3.5% (not significant) in log points. This is much less than the 35-39% (significant at 0.1% level) log points drop in the original round. During the lookback round, within ten weeks after inspectors leave, pollution increases even above prior levels (see columns (2) and (4)). While during the original round, there were still reductions (50% of the onsite period). This suggests as polluters realize the actual seriousness of central environmental inspection (In this case, there is no lasting scrutiny and punishment exerted over local polluters.), I see diminishing effects of the central crackdown.

Table 3.15: Average effects of the announcement, on-site, and post-inspection periods in the lookback round.

	Original (1) log(SO_2)	EB (2) log(SO_2)	Original (3) log(SO_2)	EB (4) log(SO_2)
Announcement	0.027	-0.013	0.027	-0.014
	(0.036)	(0.048)	(0.036)	(0.048)
On-site	-0.035	-0.032	-0.035	-0.033
	(0.033)	(0.039)	(0.033)	(0.040)
Post	0.071	0.109*		
	(0.055)	(0.061)		
Post 1-5 wks			0.043	0.073
			(0.068)	(0.075)
Post 6-10 wks			0.095*	0.138**
			(0.049)	(0.054)
Observations	60,927	45,802	60,927	45,802
R-squared	0.670	0.689	0.670	0.690
# of plants	1308	1308	1308	1308
Plant FE	Yes	Yes	Yes	Yes
Year FE	Yes	Yes	Yes	Yes
Week FE	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. Robust standard errors are given in parentheses. Standard errors are clustered at the city level.

To examine the effect of direct central attention on outranking firms, I run the same regressions as Table 2.3. Results in Table 3.16 show that differentiating upper state firms from the rest of the sample, these outranking plants reduce SO_2 more on average compared to those that do not (7.4% additional reduction in log points, significant at the 5% level). Although all plants revert back to prior levels after the inspection team leaves in the lookback round, central SOEs revert more slowly to prior levels than city SOEs. This suggests direct central attention to outranking firms helps prolong the environmental inspection effect, and ongoing scrutiny of these firms is needed to ensure adequate enforcement of environmental regulations.

Table 3.16: Effect of inspections interacted with a firm's central SOE status in the lookback round

	(1) $\log(SO_2)$	(2) $\log(SO_2)$	(3) $\log(SO_2)$	(4) $\log(SO_2)$	(5) $\log(SO_2)$
Announcement	0.030	0.039	0.031	0.030	0.030
	(0.047)	(0.049)	(0.047)	(0.047)	(0.047)
On-site	-0.005	-0.005	-0.029	-0.005	-0.005
	(0.041)	(0.041)	(0.040)	(0.041)	(0.041)
Post 1-5 wks	0.039	0.039	0.039	0.076	0.039
	(0.102)	(0.102)	(0.102)	(0.108)	(0.102)
Post 6-10 wks	0.123*	0.122*	0.123*	0.122*	0.161**
	(0.066)	(0.066)	(0.066)	(0.066)	(0.066)
Announcement× Central SOE		-0.016			
		(0.039)			
On-site× Central SOE			0.047		
			(0.029)		
Post 1-5 wks × Central SOE				-0.073	
				(0.063)	
Post 6-10 wks× Central SOE					-0.074*
					(0.044)
Observations	15,274	15,274	15,274	15,274	15,274
R-squared	0.686	0.686	0.686	0.686	0.687
# of plants	390	390	390	390	390
Plant FE	Yes	Yes	Yes	Yes	Yes
Year FE	Yes	Yes	Yes	Yes	Yes
Week FE	Yes	Yes	Yes	Yes	Yes

Note: Uses the entropy balanced power plant sample. Sample is limited to only central and lower SOE. Standard errors are clustered at the city level.

3.6.2 Incremental effect of citizen complaints

Using the same methodology in section 3.5, I quantify the environmental impact of citizens' complaints and disciplinary actions against thermal power plants during the lookback round. Table 3.17 shows the incremental effect of a complaint on the average reduction around plants in a targeted city during the lookback round. Compared with regression results from the original round (Table 3.11), there are again no incremental impacts of receiving a complaint on pollution reduction during onsite and post period. However, compared to column 4 in Table 3.11, Upper SOEs remain below average (significant at the 5% level) due to direct scrutiny of outranking firms.

Table 3.17: Effect of inspections with interactions on plants receiving a complaint in the look back round.

	(1) $\log(SO_2)$	(2) $\log(SO_2)$	(3) $\log(SO_2)$	(4) $\log(SO_2)$
Announce	-0.020	-0.013	-0.013	-0.013
	(0.048)	(0.048)	(0.048)	(0.048)
On-site	-0.032	-0.023	-0.032	-0.031
	(0.039)	(0.038)	(0.039)	(0.039)
Post	0.109*	0.109*	0.118*	0.118*
	(0.061)	(0.061)	(0.060)	(0.060)
Announce × Complaint	0.027			
	(0.023)			
On-site × Complaint		-0.034		
		(0.021)		
Post × Complaint			-0.036	0.005
			(0.032)	(0.031)
Post × Complaint × Upper SOE				-0.111*
				(0.060)
Observations	45,802	45,802	45,802	45,802
R-squared	0.689	0.689	0.689	0.690
Number of plants	1308	1308	1308	1308
Plant FE	Yes	Yes	Yes	Yes
Year FE	Yes	Yes	Yes	Yes
Week FE	Yes	Yes	Yes	Yes

Notes: 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 in parentheses. Standard errors are clustered at the city level.

3.6.3 Incremental effect of disciplinary actions

I also compare the effects of various disciplinary actions between the original round and the lookback round. Compare column (2) and (3) in Table 3.18 to those in Table 3.12, there is no significant difference between rectified plants during the onsite period. However, during the post period, firms requiring rectification reduce SO_2 more on average than those without (significant at 5% level). Differentiating upper state firms from the rest of the sample yields point estimates that suggest these outranking firms remain below average to prior polluting behavior. This is consistent with section 3.6.1 finding that as direct central scrutiny is put on outranking firms, "central SOE" problems can be resolved. Shutdown produces similar and more significant results (see Appendix table A.9). Compare column 3 in Table 3.19 and Table 3.14, plants whose behavior was connected with negligence by officials showed significantly larger drops during the post period in the look back round. In all, there are diminishing effects of central scrutiny on reducing pollution during the onsite and post period in the lookback round. This suggests local firms learn the "actual" seriousness of the program and update their expectation of punishments. However, since direct scrutiny is put on outranking SOEs in the lookback round, I see lasting effects in the post period and no reversion back to baseline level.

3.7 Conclusion

My analysis suggests that the combination of top-down pressure on local officials and citizen scrutiny has been effective in reducing SO_2 pollution in targeted provinces in the short run during the original round. The effects are apparent while the inspection team is present, and reductions, at approximately 27% below baseline levels, are substantial in human health terms. This translates into a reduction in 5-10 $\mu g/m^3$ of SO_2 on a base of 17-42 $\mu g/m^3$, although effects in badly polluted provinces were larger. However, there was no evidence of sustained air quality improvement when the inspection team revisited two years later in the lookback round. There are no significant effects of central scrutiny on plant pollution during the onsite period and a positive increase in the post period. The promise of repeat visits has not encouraged firms to adopt permanent cleanup solutions. My finding suggests that as a one-time intensified shock, environmental inspection is only effective at temporarily closing the authority gap, local bureaucrats enforcing regulation as long as a higher authority is present and paying attention. It can not close the capability gap within the city's environmental protection bureaus in interpreting the law and prosecuting cases. Improved performance does not outlast the crackdown period. This is contrary to the

Table 3.18: Direct effect of the inspections with interactions on plants requiring rectification in the look back round.

	(1) $\log(SO_2)$	(2) $\log(SO_2)$	(3) $\log(SO_2)$	(4) $\log(SO_2)$
Announce	-0.012	-0.013	-0.013	-0.013
	(0.047)	(0.048)	(0.048)	(0.048)
On-site	-0.032	-0.030	-0.032	-0.032
	(0.039)	(0.039)	(0.039)	(0.039)
Post	0.109*	0.109*	0.119**	0.119**
	(0.061)	(0.061)	(0.060)	(0.060)
Announce × Rectified	-0.013			
	(0.036)			
On-site× Rectified		-0.019		
		(0.029)		
Post× Rectified			-0.096*	-0.027
			(0.052)	(0.050)
Post× Rectified× Upper SOE				-0.164
				(0.104)
Observations	45,802	45,802	45,802	45,802
R-squared	0.689	0.689	0.690	0.690
Number of plants	446	446	446	446
Plant FE	Yes	Yes	Yes	Yes
Year FE	Yes	Yes	Yes	Yes
Week FE	Yes	Yes	Yes	Yes

Notes: Sample used in this table are limited to plants received a complaint during the inspection period.

stated goal of the inspections, to increase long-run enforcement of environmental regulations by the local bureaucrats. To overcome the weak implementation gap, the central government has to adjust the incentive structure, place more emphasis on environmental quality in local government evaluations, and improve the measurement of environmental quality on a continuous basis to overcome information asymmetry.

Unlike the campaign as a whole, the citizens' campaign itself does not seem to have been successful in reducing pollution. Within a city, those plants being named show no difference in pollution reduction compared to those not. Disciplinary actions against polluting plants and relevant officials, such as rectification or holding officials accountable, also have no lasting effect on polluting behavior. This makes us

Table 3.19: Direct effect of the inspections with interactions on plants with officials accountable in the look back round.

	(1) log(SO_2)	(2) log(SO_2)	(3) log(SO_2)	(4) log(SO_2)
Announce	-0.012	-0.013	-0.013	-0.013
	(0.048)	(0.048)	(0.048)	(0.048)
On-site	-0.032	-0.032	-0.032	-0.032
	(0.039)	(0.040)	(0.039)	(0.039)
Post	0.109*	0.109*	0.110*	0.110*
	(0.061)	(0.061)	(0.061)	(0.061)
Announce × Officials accountable	-0.108			
	(0.083)			
On-site× Officials accountable		0.082		
		(0.100)		
Post× Officials accountable			-0.146**	-0.098
			(0.067)	(0.079)
Post× Officials accountable × Upper SOE				-0.113
				(0.074)
Observations	45,802	45,802	45,802	45,802
R-squared	0.689	0.689	0.689	0.689
Number of plants	446	446	446	446
Plant FE	Yes	Yes	Yes	Yes
Year FE	Yes	Yes	Yes	Yes
Week FE	Yes	Yes	Yes	Yes

Notes: Sample used in this table are limited to plants received a complaint during the inspection period.

wonder, if citizen engagement is not effective in regulating egregious polluter behavior, why would Chinese central authorities initiate this program? I suspect citizen engagement may increase the perception of the central government's effectiveness in addressing air pollution. Another remarkable element of the program was its level of transparency. Prior environmental campaigns were often opaque, with limited dissemination of information on environmental problems, especially when issues are perceived to be politically sensitive (Xie, 2009). While the growing use of web-based platforms has made disseminating information easier than before, in the case of the campaign I study here, transparency and citizens' involvement was an explicit goal. The sources used in this study were very detailed: the schedules that inspectors would follow, the complaints filed by citizens, and the officials found to be neglecting duties were all readily available online. The media's likening of inspections to approaches used in imperial China may strengthen the perception of the centrals' effort. Involving citizens could thus shore up government credibility in a time of (environmental) crisis. These benefits could accrue to the crackdown's originators, even if there is no lasting effect on pollution. However, these benefits may erode if citizens discover pollution reductions do not last.

By directly targeting central SOEs in the lookback round, I find these outranking firms revert more slowly to prior polluting behaviors than local SOEs. Although hierarchy matters, as discussed in Chapter 2, if the central government adjust the incentive structure to ensure outranking firms are consistently monitored and face the same punishment risks relative to local SOEs and private firms, one may resolve the "central SOE problem" (Eaton and Kostka, 2017).

Chapter 4

Why participate? Understanding the drivers of citizen complaints during China's environmental inspections

4.1 Introduction

Why should one care about identifying drivers of citizen complaints in authoritarian environmental governance? In Chapter 3, I document the widespread community interest in reporting environmental problems to officials. However, the specific setting of the environmental inspection makes it difficult to extrapolate to broader policy consequences. The magnitude and efforts for promoting the usage of the complaint system were overwhelming, and the central government was physically on-site to supervise the entire process. Community monitoring initiatives created by local governments, such as the "Environmental Hotline Platform 12369" and the "Black and Smelly Waters Program", may lack this degree of transparency and responsiveness. Evidence on the effectiveness of these citizen participation programs is mixed (Kostka and Zhang, 2018; Shin, 2018; Wang, 2018) due to the low participation rate and absence of a sanction mechanism.

I analyze the long accountability route using the "citizen-state-provider" framework described in Chapter 1, where citizens are the ultimate principal demanding welfare benefits from the agent, the state. Local bureaucrats administer the environmental protection program on polluters in response to popular demand. In the case of environmental inspection, the bottom-up citizen monitoring approach may act as supplemental monitoring capacity and reduce the workload of local EPB. From a theoretical perspective, identifying what city and plant characteristics predict the number of per capita complaints indicates which policies may be useful for increasing citizen participation.

From policy implications, there is historical evidence on the participation of environmental community monitoring programs in democratic settings: Huet-Vaughn et al. (2018) suggests that providing citizens with real-time visual evidence of emissions affects the frequency of complaints received at monitored facilities. Similar evidence is observed at the firm level in German companies (Frondel et al., 2004). There is also substantial evidence of popular support for mitigating air pollution (Stokes and Warshaw, 2017). This raises the question of why individuals would participate in government-initiated citizen-based monitoring programs in an authoritarian regime. There is evidence that public engagement in local regulatory activities increased as a result of monitoring programs in China (Hsu et al., 2020; Grossman et al., 2017). However, Flatø (2019) highlights the limited desire of Chinese citizens to raise concern to their local authorities for greater environmental protection.

I report two main findings. First, I ask how ambient pollution levels in citizens' residential locations affect the level of complaints received. My finding indicates that cities with low environmental performance at baseline receive a greater number of per capita complaints during both rounds of the environmental inspection. However, citizens can not identify and report specific plants that polluted more in the baseline period. This suggests that citizens are aware of the overall environmental quality within their vicinity, but are unable to identify specific egregious polluters. Second, I ask whether citizens' willingness to file complaints is contingent on the environmental effectiveness of prior complaints. At the city level, during the lookback round, I see a decline in air-related complaints in cities with higher levels of reversion to baseline pollution after the original inspection round. However, in the lookback round, citizens do not complain more about plants that keep pollution below baseline after the inspection team leaves in the original round.

This chapter is structured as follows. Section 4.2 provides a brief review of relevant literature. Section 4.3 describes my data source. Section 4.4 discusses my results on city characteristics that determine the per capita complaints received during the environmental inspection. Section 4.5 summarizes my findings on plant attributes that predict whether or not a facility receives at least one complaint. Section 4.6 analyzes the lookback round of the environmental inspection and asks if the number of citizen complaints in a subsequent inspection round changes as a function of the measured environmental effectiveness (extent of reversion to baseline pollution, using the average of city monitors) of complaints in previous rounds? Section 4.7 reflects on the implications of my findings.

4.2 Literature Review

I draw on past literature that identifies possible predictors of complaints against environmental problems to identify drivers of citizen complaints. First, the economic and social status of citizens may affect citizens' efficacy towards environmental issues. Higher willingness-to-pay (WTP) and stronger support for public environmental spending are found among urban, higher-income, higher-educated, and higher-occupational status individuals (Chen et al., 2018; Ito and Zhang, 2020; Park, 2010). I ask if individuals residing in cities with better quality of life (specifically, access to better environment, health, and education) are more likely to file complaints against local polluters. Given citizens' perceptions of local environmental (especially air) quality affect their WTP (Sun et al., 2019; Wang et al., 2016) and environment-related behaviors (Aregay et al., 2018), I check if the above hypothesis is mitigated by air quality as individuals who live in polluted areas express more desire for environmental protection.

Second, local government institutional characteristics such as citizens' access to pollution information and governments' response rate also affect citizens' desire to participate in environmental monitoring programs. Brombal (2019) point to the limitation for Chinese environmental agencies to provide consistent, publicly available environmental data, especially in poor, underdeveloped regions. However, there is mixed evidence on whether providing citizens with access to information is effective in increasing participation. (Hsu et al., 2017) find lack of information on the quality of service provision and government process usually prevent citizens from voicing their concerns. Lieberman et al. (2014), instead, finds no impact of providing information on the quality of service on private or public citizen action in Rural Kenya. I also investigate if government efficiency influences citizens' participation rate. Studying Portuguese municipalities, (Tejedo-Romero et al., 2022) find efficient governments are better at facilitating citizen participation and increasing citizens' involvement in regulatory space.

Third, local environmental characteristics may also affect the level of citizen participation in the environmental monitoring program. Globally, studies found that scientifically measured pollution influenced support for environmental policy, perceptions, and attitudes (Brody et al., 2008; Zahran et al., 2006). In China, measured air pollution in residents' locations affected environmental complaints (Dasgupta and Wheeler, 1997), WTP Tang and Zhang (2016), and political participation Alkon and Wang (2018). I ask if ambient air pollution levels measured at baseline affect citizens' desire to express environmental concerns.

Fourth, I examine what local industry/polluter characteristics predict whether a facility receives at least one complaint. I test if firm accountability influence citizen participation. State-owned firms in China are differentiated by their accountability to their respective levels of China's governing hierarchy (See Chapter 2.6). Plants not directly accountable to city-level government sometimes escape punishment when facing environmental violation accusations (Eaton and Kostka, 2017). I examine if citizens' decision to file a complaint is affected by the firms' ownership type and their oversight ties within the government.

Given the complaint channel is open to the public twice, once in the original round and again in the lookback round, I investigate the dynamic effect between historical interaction and present political participation. "Informed disengagement" (Gallagher, 2006) describes that an increase in internal efficacy coupled with a decrease in external efficacy does not lead to despondency but to more informed actions by legal plaintiffs in China. Croke et al. (2016) documents "deliberate disengagement" among educated citizens in electoral authoritarianism as they realize participation is futile. I intend to test if the same situation holds for environmental governance: when citizens become disillusioned with the government's responsiveness, how will their political participation change? I explore the difference in the incidence of complaints between the two inspection rounds to understand the effect of first round interaction on political participation in the second round.

4.3 Data construction

To generate comprehensive indices of local government's characteristics, I rely on three sources: (i) world bank survey of governance, investment climate, and harmonious society index for 120 cities in China (World Bank, 2006); (ii) pollution information transparency index provided by Institute of Public and Environmental Affairs (IPE).[1] IPE, a non-profit organization, develops this index annually based on field expert study and reporting platform evaluation. Green Data, another non-profit organization that provides publicly available environmental data, also publishes their open-government assessment[2] and I will use it as a robustness check; and (iii) social-

[1] Annual reports can be accessed at `http://wwwen.ipe.org.cn/reports/Reports_18336_1.html`.

[2] Annual reports can be accessed at `http://www.lvwang.org.cn/article/show?id=101`.

economic data collected from the statistical yearbook. I will use “CEIC Data” to collect population, GDP, dirty sector industrial share, etc., to create comprehensive city-level baseline statistics.

4.3.1 Indicators for quality of life

World bank surveyed 120 cities on local government efforts to provide a better quality of life indicated by regional differences in environment, health care, education, and prosperity. Eight performance indicators measuring localities' livability are provided.

- Environmental indicators: three variables are included, the percentage of industrial waste disposal that meets environmental protection standards (variable “Ind waste disp (%)”), square meters of per capita green space (variable “Per capita green (m^2)”), and the percentage of days a city has good or excellent air quality (variable “Better air quality (%)”).

- Health care indicators: infant mortality rate per 1000 (variable “Infant mort (per 1000)”), and the share of permanent workers with health insurance coverage (variable “workers health ins (%)”).

- Education indicators: per capita expenditures on education spending in RMB (variable “Workers health ins (%)”), and the share of female students in total enrollment (variable “female enroll (%)”).

- Prosperity indicator: the annual average wage (variable “annual wage (RMB)”).

4.3.2 Indicators for pollution information disclosure

“Pollution information transparency index” (PITI) provided by IPE measures the local environmental protection bureau (EPB)'s efforts in disclosing environmental information for 120 cities. It covers six primary indicators, and each indicator is measured using four dimensions (systematicness, completeness, timeliness, and user-friendliness). Scores are assigned to each indicator with a total of 100 points. The six indicators included in the regressions are:

- Disclosure status of data on enterprise's excess emissions and other daily violation records (variable "Daily violation").

- EPB's publication on their evaluation of corporate environmental performance and credit ratings (variable "Environ perform").

- Quality of data obtained through automatic monitoring platform and its subsequent platform development (variable "Autom monitoring").

- Disclosure of information on the handling of environmental reports and complaints received by EPBs (variable "Complaints & rep").

- Disclosure of annual pollutant emission data for key state-monitored enterprises (variable "Emis of key ent").

- Disclosure status of the full text of environmental impact assessment reports (variable "EIA").

4.3.3 Indicators for government responsiveness

World bank's survey of 120 cities also checks for government efficiency in terms of regulatory simplification, the rule of law and quality of service, and balance for firm ownership. Six indicator variables are included in the regressions.

- Government efficiency measurement: three variables are included, district-average of the effective tax burden of firms (variable "Taxes & fees (%)"), measured as total taxes and fees over value-added. Time-cost of dealing with bureaucracies (variable "Bureau interact (days)"), measured as the total number of days-per-year that the firm spends dealing with various agencies. And local firms' average output losses due to problems with power or transport infrastructure (variable "output losses (%)").

- The rule of law measurement: the likelihood that firms' contract rights are protected and enforced (variable "Confid in courts (%)").

- Skills of government official measurement: percentage of workers with a university education (variable "University educated (%)").

- Share of private sector firms and state-owned enterprises (variable "Private firms (%)").

4.3.4 Indicators for measured pollution level

I assemble hourly air quality data for four major pollutants SO_2, NO_X, $PM_{2.5}$ and PM_{10} measured as ambient concentration ($\mu g/m^3$) at the level of individual monitors. All hourly air quality measures are averaged at the weekly level to reduce noise. City-level pollution is measured as the average of all monitors within that localities. On average, there are five monitors per city. Baseline pollution level is defined as the average concentration of major pollutants 5 to 10 weeks prior to the citizen complaint channel is open.

4.4 Factors affecting per capita complaints at city level

I identify city characteristics that determine the per capita complaints received during the environmental inspection. I examine the following four factors: local quality of life (e.g., environment, health care), citizens' access to pollution information, local government efficiency, and baseline pollution level.

- Local quality of life: My hypothesis is individuals who reside in cities with better quality of life (specifically, access to better environment, health, and education) are more likely to file complaints against local polluters. However, this is mitigated by air quality as individuals who live in polluted areas express more concerns for environmental protection.

- Information transparency and disclosure: My hypothesis is providing an avenue for information disclosure documents local governments' attention to clean pollution and can potentially decrease citizen participation.

- Government efficiency and effectiveness: My hypothesis is localities with less efficient governments receive a lower rate of citizen complaints.

- Baseline pollution level: My hypothesis is higher local concentrations of pollutant increase the probability that citizens express a desire for environmental protection by local government

To quantitative test my hypothesis, I estimate the following ordinary-least-squares (OLS) regression:

$$Y_i = \alpha_0 + \alpha_1 \text{Index}_i + \alpha_2 \text{City}_i + \epsilon_i$$

Here, the dependent variable is the total number of complaints received during the environmental inspection in a city divided over per million people. Besides the total number of complaints, I also differentiate across pollutant types (air, water, soil, noise, ecology, and other). The main variable of interest is Index_i. I use proxies to measure the level of pollution information disclosure, government efficiency, and quality of life. For the information disclosure hypothesis, I use the "pollution information transparency index" (PITI) provided by Institute of Public and Environmental Affairs (IPE). For the local quality of life and government efficiency hypothesis, I use the world bank's survey of 120 cities measuring government effectiveness and quality of life (economy, health, education, and environment). For the baseline pollution level hypothesis, I use the city's average pollutant concentration generated from ground-level monitors. To control for confounders, City_i includes city-level specific socio-economic characteristics such as per capita income, fixed asset investment, electricity usage, annual SO_2 and dust emissions generated from the annual statistical yearbook. My major variable of interest is the significance and direction of coefficient α_1.

4.4.1 Information disclosure

Results is shown in Table 4.1. Cities with worse automatic monitoring data disclosure systems and worse disclosure of enterprise environmental performance/credit rating systems are more likely to receive a higher number of per capita complaints across all categories. Cities with better environmental information disclosure systems and higher transparency have fewer complaints.

Table 4.1: OLS regression relating indices measuring level of pollution information transparency and disclosure to the number of complaints received

	Total	Air	Water	Soil	Noise	Ecology	Other
Daily violation	2.181	2.071*	1.052	0.294	0.455	0.635	0.199
	(1.858)	(1.164)	(0.642)	(0.391)	(0.730)	(0.612)	(0.481)
Environ perform	-22.70**	-15.09**	-4.070	-6.778***	-5.762	-5.858*	-7.362***
	(9.262)	(5.803)	(3.201)	(1.951)	(3.640)	(3.049)	(2.398)
Autom monitoring	-11.55***	-6.400***	-2.050**	-2.253***	-4.164***	-2.492***	-0.644
	(2.746)	(1.720)	(0.949)	(0.578)	(1.079)	(0.904)	(0.711)
Complaints & rep	-1.119	-0.119	-1.357	-0.455	-0.180	-2.526	0.171
	(4.602)	(2.884)	(1.591)	(0.969)	(1.809)	(1.515)	(1.191)
Emis of key ent	4.525	3.182	1.812	0.213	1.991	0.341	0.878
	(3.864)	(2.421)	(1.335)	(0.814)	(1.519)	(1.272)	(1.000)
EIA	5.511	3.663	2.272*	1.057	1.831	1.704	0.750
	(3.846)	(2.410)	(1.329)	(0.810)	(1.511)	(1.266)	(0.996)
Observations	67	67	67	67	67	67	67
R-squared	0.427	0.424	0.320	0.439	0.340	0.333	0.273

Besides the simple regression, I also look at interaction effects as information asymmetry should only be effective for dirty cities as citizens who reside in clean cities do not necessarily file complaints against local polluters. My hypothesis is better information disclosure will have more significant effects on dirtier cities. Result shown in Appendix table A.10 is consistent with the hypothesis. Interaction terms with automatic monitoring suggest cities with better information disclosure systems receive fewer complaints in general.

4.4.2 Local quality of life

Results is shown in Table 4.2. The percentage of female enrolled students in a city predicts a higher number of per capita complaints across all categories. Other life quality indices have null effects associated with complaints received besides health indicators for noise complaints. Cities with a lower percentage of days with good air quality are more likely to receive a higher number of per capita complaints and air-related complaints.

Table 4.2: OLS regression relating indices measuring local quality of life to the number of complaints received

	Total	Air	Water	Soil	Noise	Ecology	Other
Ind waste disp (%)	0.299	0.535	0.339	0.0609	0.0494	-0.0772	0.453
	(1.341)	(0.814)	(0.445)	(0.279)	(0.500)	(0.439)	(0.326)
Per capita green (m^2)	1.382	0.911	0.534	0.469	0.371	0.181	0.569
	(1.515)	(0.920)	(0.503)	(0.316)	(0.565)	(0.497)	(0.369)
Better air quality (%)	-1.190*	-0.739*	-0.133	-0.286**	-0.384	-0.158	-0.126
	(0.682)	(0.414)	(0.226)	(0.142)	(0.254)	(0.223)	(0.166)
Infant mort (per 1000)	3.973	1.754	0.893	0.639	2.127**	1.198	0.586
	(2.663)	(1.617)	(0.884)	(0.555)	(0.992)	(0.873)	(0.648)
Workers health ins (%)	1.289	0.707	0.397	0.238	0.623**	0.319	0.264
	(0.792)	(0.481)	(0.263)	(0.165)	(0.295)	(0.260)	(0.193)
Per capita educ (RMB)	0.00304	0.00609	-0.00106	8.04e-05	-0.00160	-0.000263	0.00503
	(0.0214)	(0.0130)	(0.00712)	(0.00447)	(0.00799)	(0.00703)	(0.00522)
Female enroll (%)	6.160**	4.152**	2.313**	1.568**	2.152*	1.710*	1.443**
	(2.947)	(1.790)	(0.978)	(0.614)	(1.098)	(0.966)	(0.717)
Annual wage (RMB)	-2.04e-05	0.000924	0.000847	-0.000598	-0.000198	-0.000443	-0.000429
	(0.00274)	(0.00166)	(0.000908)	(0.000570)	(0.00102)	(0.000896)	(0.000665)
Observations	67	67	67	67	67	67	67
R-squared	0.252	0.288	0.234	0.213	0.241	0.117	0.197

Besides the simple regression, I also look at interaction effects for the quality of life indicators. My hypothesis is that people with better quality of life will be more willing to pay for clean air. Thus, the effect will be higher for those cities with better quality of life. Result shown in Appendix table A.11 contradicts the hypothesis. Interaction term with female enrollment percentage and other indices suggest cities with better life quality shows no difference in the number of complaints received.

4.4.3 Government effectiveness and efficiency

Results is shown in Table 4.3. Wealthier cities and cities with fewer private firms are more likely to receive a higher number of per capita complaints. Cities where firms experience a higher percentage of output losses due to power and transport inadequacy, have more per capita complaints. Longer bureaucratic interaction and less confidence in courts do not affect per capita air-related complaints.

Table 4.3: OLS regression relating indices measuring government effectiveness to the number of complaints received

	Total	Air	Water	Soil	Noise	Ecology	Other
log(per_capita)	42.10*	32.60**	12.44	5.222	9.157	-0.202	4.956
	(22.08)	(13.74)	(7.674)	(4.587)	(8.251)	(7.457)	(5.993)
Taxes & fees (%)	14.04	7.954	3.810	3.316*	5.610	5.678*	1.916
	(9.137)	(5.685)	(3.176)	(1.898)	(3.415)	(3.086)	(2.480)
Bureau interact (days)	-0.102	-0.0531	-0.131	0.0205	-0.136	-0.0460	-0.0469
	(0.558)	(0.347)	(0.194)	(0.116)	(0.209)	(0.189)	(0.152)
Output losses (%)	15.45***	9.517***	5.687***	2.522**	5.375***	4.151***	2.012
	(4.554)	(2.834)	(1.583)	(0.946)	(1.702)	(1.538)	(1.236)
Confid in courts (%)	0.715	0.412	0.166	0.242*	0.271	0.198	0.163
	(0.668)	(0.416)	(0.232)	(0.139)	(0.250)	(0.226)	(0.181)
University educated (%)	2.178	1.087	0.123	0.234	1.669**	0.451	0.404
	(1.893)	(1.178)	(0.658)	(0.393)	(0.707)	(0.639)	(0.514)
Private firms (%)	-3.555***	-2.150***	-0.619	-1.004***	-0.745	-0.874*	-0.663*
	(1.291)	(0.803)	(0.449)	(0.268)	(0.483)	(0.436)	(0.350)
Observations	67	67	67	67	67	67	67
R-squared	0.473	0.473	0.408	0.449	0.462	0.339	0.295

4.4.4 Baseline pollution level

Results is shown in Table 4.4. Cities with worse baseline air quality are more likely to receive a higher total number of per capita complaints. The effect is significant for SO_2 and NO_X.

Table 4.4: OLS regression relating baseline pollution level to the number of complaints received

	Total	Total	Total	Total	Total
log(per capita)	41.69***	42.72***	45.91***	42.88***	43.63***
	(14.70)	(14.78)	(15.20)	(15.24)	(15.14)
log(fixed asset inv)	-5.477	-13.28	-10.36	-9.539	-10.45
	(9.510)	(9.679)	(9.595)	(9.770)	(9.802)
log(elec usage)	10.81	8.292	9.200	8.730	9.083
	(6.578)	(6.545)	(6.619)	(6.659)	(6.669)
log(annual SO_2 emi)	-1.452	4.972	3.532	3.428	3.337
	(8.909)	(8.718)	(8.773)	(8.852)	(8.822)
log(annual dust emi)	3.196	1.976	4.362	6.312	5.468
	(7.026)	(7.290)	(7.221)	(7.272)	(7.277)
Baseline_SO_2	0.507**				
	(0.211)				
Baseline_NO_X		1.099**			
		(0.528)			
Baseline_PM_{25}			0.374		
			(0.283)		
Baseline_PM_{10}				0.0636	
				(0.192)	
Baseline_AQI					0.182
					(0.250)
Observations	150	150	150	150	150
R-squared	0.252	0.244	0.231	0.222	0.224

4.5 Factors predicting complaints about power plants

In order to understand what attributes may have affected the filing of complaints against power plants, I test for the predictive effect of a set of factors on whether a power plant receives complaints. I conduct a logistic regression using the following list of covariates: (i) city characteristics of per-capita income and population level; (ii) firm characteristics of geographical location, revenue share, company age, ownership, and oversight level;[3] and (iii) SO_2 concentrations in the baseline period (5 to 10 weeks prior to the arrival of the central inspection team). My sample is comprised of all

[3]I introduce heterogeneity by differentiating accountability to "upper" levels (provincial and national governments, here an "Upper SOE"), which outrank the city government, and "lower" levels (city and below, here a "Lower SOE"), which are subordinate to the city government.

1308 power plants within the eight sample provinces.

$$Ln(P_i/1 - P_i) = \alpha_0 + \alpha_1 \text{City}_i + \alpha_2 \text{Plant}_i + \alpha_3 \text{Environ}_i + \epsilon_i$$

Predictors of a plant receiving a complaint are shown in Table 4.5. 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, 2020). Moreover, citizens in wealthier cities may be more aware of the health consequences of degraded air. Population density also positively predicts complaints, as more citizens are able to identify and report a polluting firm located in the surrounding urban or industrial areas. Company age negatively predicts complaints. State oversight, upper or lower, is not systematically correlated with receiving complaints.

Compared to the original round, Table 4.6 shows population density and fixed asset investment no longer predict whether a plant received a complaint or not in the lookback round.

4.6 Factors predicting citizen complaints in the look-back round

In 2018, central inspection teams were again dispatched for a "look back" round to evaluate progress in addressing violations discovered in the first round. In this section, I investigate the dynamic effect between historical interaction and present political participation. "Informed disengagement" (Gallagher, 2006) describes that an increase in internal efficacy coupled with a decrease in external efficacy does not lead to despondency, but to more informed actions by legal plaintiffs in China. Croke et al. (2016) documents "deliberate disengagement" among educated citizens in electoral authoritarianism as they realize that participation is futile.

Table 4.5: Logit regression relating firm/city characteristics to complaint status in the original round.

	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)	(9)	(10)	(11)	(12)
log(per capita)	0.44***											0.58**
	(0.12)											(0.26)
log(pop dens)		0.14*										0.00
		(0.08)										(0.15)
log(fixed asset inv)			0.12*									0.02
			(0.07)									(0.15)
log(elec usage)				0.03								-0.14
				(0.05)								(0.11)
log(annual SO_2 emi)					0.12							0.17
					(0.08)							(0.16)
log(annual dust emi)						-0.07						0.10
						(0.06)						(0.12)
log(dist to center)							-0.04					-0.03
							(0.06)					(0.07)
revenue share city								0.28				0.21
								(1.09)				(1.18)
company age									-0.01			-0.01
									(0.00)			(0.01)
upper SOE										0.08		0.11
										(0.12)		(0.15)
baseline SO_2											-0.00	-0.00
											(0.00)	(0.00)
Observations	1,420	1,420	1,420	1,405	1,420	1,420	1,429	1,094	1,098	1,429	1,258	932
Pseudo R2	0.00811	0.00165	0.00162	0.000199	0.00127	0.000682	0.000328	4.70e-05	0.00136	0.000264	8.46e-08	0.0129

Notes: Uses the eight-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). 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 4.6: Logit regression relating firm/city characteristics to complaint status in the lookback round.

	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)	(9)	(10)	(11)	(12)
log(per capita)	0.24*											0.36
	(0.14)											(0.29)
log(pop dens)		-0.11										-0.11
		(0.09)										(0.16)
log(fixed asset inv)			-0.06									-0.06
			(0.08)									(0.17)
log(elec usage)				0.01								0.03
				(0.06)								(0.13)
log(annual SO_2 emi)					-0.14							-0.10
					(0.09)							(0.18)
log(annual dust emi)						-0.09						0.12
						(0.07)						(0.14)
log(dist to center)							-0.08					-0.07
							(0.07)					(0.08)
revenue share city								0.88				0.57
								(1.21)				(1.34)
company age									0.00			0.01
									(0.00)			(0.01)
upper SOE										0.14		0.26
										(0.14)		(0.18)
baseline SO_2											-0.00	-0.00
											(0.00)	(0.00)
Observations	1,206	1,206	1,206	1,191	1,206	1,206	1,215	932	936	1,215	1,064	789
Pseudo R2	0.00227	0.00127	0.000424	4.03e-05	0.00187	0.00143	0.00117	0.000506	8.13e-05	0.000771	0.00117	0.00855

Notes: Uses the eight-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). 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.

4.6.1 City-level

To examine if citizens reduced usage of the complaint channel based on the environmental effectiveness of the original round, I estimate a ordinary-least-squares (OLS) regression. My hypothesis is: Air-related complaints received in the look-back round will decrease if there is a reversion to the baseline pollution level for measured air pollutants after the original round ends. There will be null effects for not air-related complaints.

$$\Delta_i = \alpha_0 + \alpha_1 \text{Rever}_i + \alpha_2 \text{City}_i + \alpha_3 \text{Season}_i + \alpha_4 \text{Year}_i + \epsilon_i$$

Dependent variable Δ_i is the difference between the total number of air and non-air related complaint in look-back and original rounds in a city divided over per million people. Rever_i is the difference between the average pollutant concentration in each city between the post period and the baseline period. The post period is defined as the average pollutant concentration 1 to 10 weeks after the complaint channel is closed. City_i controls for city-specific socio-economic characteristics such as population, GDP, fixed asset investment, electricity usage, environmental performance such as annual SO_2, and dust emissions generated from the annual statistical yearbook. My major variable of interest is the significance and direction of coefficient α_1. Season_i is an indicator variable accounting for seasonal effects. It is defined as the date complaint was filed in the original round. Year_i is an indicator variable accounting for the time trend.

Table 4.7 shows that if the air quality during the 12-week post period is, on average, worse than the baseline period, I see a decrease in air-related complaints during the lookback round. In table 4.8, compared to air-related problems, a short-term reversal in air quality does not predict significant result for the number of non-air-related complaints.

I also conduct a set of robustness checks. First, I check for another way of measuring the baseline period. I define baseline as 1-10 weeks prior to the opening of the complaint channel. Results are shown in Appendix table A.12 and A.13. It has

Table 4.7: Relationship between short-term environmental performance change and delta of number of air-related complaints per million people received.

	ΔAir	ΔAir	ΔAir	ΔAir	ΔAir
log(per capita)	-11.94	-12.69*	-12.05	-11.41	-12.10
	(7.477)	(7.577)	(7.579)	(7.429)	(7.599)
log(fixed asset inv)	-0.897	0.0866	0.435	0.362	0.124
	(4.598)	(4.652)	(4.617)	(4.527)	(4.620)
log(elec usage)	2.674	3.398	2.892	2.483	2.969
	(3.280)	(3.314)	(3.329)	(3.257)	(3.336)
log(annual SO_2 emi)	1.151	0.129	0.412	1.032	0.255
	(4.176)	(4.347)	(4.209)	(4.117)	(4.209)
log(annual dust emi)	1.106	0.149	0.286	0.331	0.398
	(3.409)	(3.441)	(3.417)	(3.353)	(3.428)
Rever SO_2	-0.219*				
	(0.114)				
Rever NO_X		-0.104			
		(0.356)			
Rever PM_{25}			-0.201		
			(0.203)		
Rever PM_{10}				-0.332**	
				(0.140)	
Rever AQI					-0.135
					(0.170)
Observations	130	130	130	130	130
R-squared	0.224	0.201	0.207	0.236	0.205

similar effects as the previous definition. Significant results for air-related complaints and null results for non-air-related complaints. Second, I check for another way of measuring reversion, defining reversion as post-complaint pollution is greater than the on-site period. Results are robust as the previous definition shown in Appendix table A.14 and A.15.

4.6.2 Plant-level

To examine if citizens update their decision on whether to file a complaint against polluters based on the environmental effectiveness of the original complaint, I estimate

Table 4.8: Relationship between short-term environmental performance change and delta of number of non air-related complaints per million people received.

	ΔNonair	ΔNonair	ΔNonair	ΔNonair	ΔNonair
log(per capita)	8.909*	9.188*	9.659*	9.859*	9.537*
	(5.190)	(5.195)	(5.195)	(5.142)	(5.215)
log(fixed asset inv)	-7.039**	-7.530**	-7.232**	-7.317**	-7.452**
	(3.192)	(3.189)	(3.164)	(3.133)	(3.171)
log(elec usage)	-0.175	-0.335	-0.727	-0.850	-0.621
	(2.277)	(2.272)	(2.282)	(2.254)	(2.290)
log(annual SO_2 emi)	-2.460	-1.662	-1.551	-1.353	-1.728
	(2.898)	(2.980)	(2.885)	(2.849)	(2.888)
log(annual dust emi)	1.685	1.876	2.002	2.015	2.065
	(2.367)	(2.359)	(2.342)	(2.321)	(2.352)
Rever SO_2	-0.0694				
	(0.0792)				
Rever NO_X		-0.107			
		(0.244)			
Rever PM_{25}			-0.150		
			(0.139)		
Rever PM_{10}				-0.177	
				(0.168)	
Rever AQI					-0.0836
					(0.117)
Observations	130	130	130	130	130
R-squared	0.183	0.179	0.185	0.200	0.181

a logit regression:

$$Log\frac{P(\text{Plant}_i)}{1-P(\text{Plant}_i)} = \alpha_0 + \alpha_1 1(\text{Rever}_i) + \alpha_2\text{City}_i + \alpha_3\text{Plant}_i + \alpha_4\text{Season}_i + \alpha_5\text{Year}_i + \epsilon_i$$

Limiting the sample to plants receiving complaints in the original round, I check if the same disillusion effect holds at the plant level. My dependent variable Plant_i equals one if the plant receives a complaint again in the lookback round. Rever_i is the difference between the average pollutant concentration for this plant between the post period and the baseline period. The post period is defined as the average pollutant concentration 1 to 10 weeks after the complaint channel is closed. City_i controls for city-specific socio-economic characteristics such as population, GDP, fixed asset investment, electricity usage, environmental performance such as annual SO_2 and dust emissions generated from the annual statistical yearbook. Plant_i controls for plant-specific characteristics such as geographical location, revenue share, company age, ownership, and oversight level. Season_i and Year_i are indicator variable controls for seasonal variation and time trend. My major variable of interest is the significance and direction of coefficient α_1.

Table 4.9 shows that during the lookback round, citizens do not complain more about plants that keep pollution below baseline after the inspection team leaves in the original round.

Table 4.9: Logit regression relating reversion in the original round to complaint status in the lookback round.

	(1)	(2)	(3)	(4)
log(per capita)	0.67	0.62	0.58	0.60
	(0.51)	(0.51)	(0.51)	(0.51)
log(pop dens)	0.16	0.17	0.18	0.19
	(0.28)	(0.28)	(0.28)	(0.28)
log(dist to center)	0.08	0.11	0.09	0.09
	(0.15)	(0.15)	(0.15)	(0.15)
revenue share city	0.24	0.61	0.62	0.61
	(1.52)	(1.45)	(1.46)	(1.45)
company age	0.00	0.00	0.00	0.00
	(0.01)	(0.01)	(0.01)	(0.01)
upper SOE	0.35	0.37	0.35	0.36
	(0.29)	(0.29)	(0.29)	(0.29)
Rever SO_2	0.01			
	(0.01)			
Rever NO_X		0.01		
		(0.02)		
Rever_$PM_{2.5}$			-0.00	
			(0.01)	
Rever_PM_{10}				0.00
				(0.01)
Observations	278	278	278	278
Pseudo R2	0.0334	0.0304	0.0291	0.0291

4.7 Conclusion

Given the limitation of bureaucratic accountability (discussed in Chapters 2 and 3) in filling the policy implementation gap at the local level, the central government could consider another accountability route, bottom-up monitoring by citizens. This chapter identifies contingent factors central government should consider when designing programs to solicit citizen reporting on environmental problems. I ask, what are the attributes predicting the level of citizen complaints? Better access to pollution information lowers the complaints rate across all pollutant categories. Lieberman et al. (2014) argues that for information to induce citizen participation, three conditions must be met: first, citizens must fully understand the content of the information. Second, information has to update citizens' incentives and beliefs to take action. Third, citizens must have the skills and knowledge needed to engage effectively. In the case of environmental monitoring, citizens can not identify and report specific plants that polluted more in the baseline period with the information technologies that exist. This suggests they either lack the training to interpret pollution information or are not motivated to file complaints. I believe a qualitative study understanding citizens' perception of the central-initiated complaint channel is needed for future research direction. Citizens who reside in wealthy areas are more likely to file complaints, but access to health care and education is not associated with the number of complaints. This confirms Ito and Zhang (2020)'s finding that wealthier people are more sensitive to plant pollution and have higher WTP for clean air. When designing a program that encourages bottom-up monitoring, the central government should be aware of this bias and put greater emphasis on understanding the need of poor citizens to achieve environmental justice.

I further ask whether citizens' willingness to file complaints depends upon the result of previous complaints. I show as citizens realize that complaints filed in the original round are futile, the participation rate in these reporting channels reduces. At the city level, per capita air-related complaints received in the lookback round will decrease if there is a reversion to the baseline pollution level for measured air pollutants after the original round ends. In the original round, the complaint channel may temporarily grant citizens agency in fighting environmental pollution in their immediate vicinity, in the process raising their awareness of the state's corrective efforts. Public announcements of how complaints were addressed signaled responsiveness and may have placated those most likely to complain. All help the Chinese central state to regime legitimacy in the eyes of citizens. However, as citizens discover pollution reductions do not last, and citizen reporting have no incremental effect on plant emission reduction, they no longer participate in these central-initiated citizen monitoring program. The central government may face additional threats to regime stability.

In all, this chapter contributes to the literature studying how citizens can hold politicians more accountable for environmental performance, either by increasing their influence in the policy-making process or aligning their interest with the central state (World Bank, 2004). Without the traditional voice mechanisms in democratic settings, such as elections and informed voting, Chinese citizens will have to voice their concerns and threaten regime legitimacy to ensure actions are taken to improve local environmental quality. Nongovernmental and civil society organizations may also help to amplify citizens' environmental concerns, thus improving accountability.

Chapter 5

Conclusion

Although environmental regulations may be well-designed, in practice, their implementation at the local level is usually incomplete (Keohane et al., 2009; McAllister et al., 2010; Duflo et al., 2013). Using the unique empirical context of China's environmental inspection campaign, this dissertation examines the roots of the enforcement gap in China's environmental politics: a lack of state capacity to monitor policy implementation and a perverse incentive structure that prioritizes economic growth. The short-lived decrease in SO_2 emission during the environmental inspection implies that a one-time intensification of monitoring and sanctions cannot increase bureaucratic accountability and polluter compliance over the long run. To improve environmental performance over the long term, the central government may need to spend efforts to improve the measurement of environmental quality on a continuous basis [1] and adjust the incentives structure to place a higher focus on environmental quality in the performance evaluations of local cadre.

This chapter is structured as follows. First, I recap the main findings of each chapter of the thesis and summarize the implications for future research and policy. Then, I integrate the lessons from the separate chapters of this dissertation to formulate policy suggestions.

[1] In recent years, the Ministry of Ecology and Environment has developed the air pollution monitoring network, requesting municipalities to establish ground-level monitoring stations and plants install continuous emissions monitoring systems (CEMS). However, law enforcement does not yet utilise these platforms for litigation purpose.

5.1 Effect of central inspection on polluter response

In Chapter 2 of this dissertation, I investigate the bureaucratic origins of the enforcement gap in China at the ground level. I evaluate how a centrally-led crackdown, in the form of rotating environmental inspections, influenced coal power plant pollution over time. I estimate the impacts using high-frequency, plant-level data on the concentrations of sulfur dioxide (SO2), a prominent short-lived industrial air pollutant. I discover that while inspections are in progress, pollution falls by 34-37%, a substantial decrease. However, after inspectors leave the locality, pollution returns to pre-inspection levels within approximately two months. Reversion occurs most rapidly among firms accountable to the central government, which originated the inspections, while cleanup persists longer among firms accountable to the local government. I investigate the mechanisms by which plants adjust pollution during and after inspections by examining how pollution responds to inspections. Plants reduced pollution during inspections mainly by operating scrubbers. Reversion after inspectors is higher at plant with scrubbers and is associated with increased output.

5.1.1 Implications for research

This work contributes to a growing literature in economics that analyzes the impact of crackdowns (Eeckhout et al., 2010; Johannesen and Zucman, 2012; Dell, 2015) by quantifying the dynamic effects of China's rotating environmental inspections on high-frequency pollution measurements at coal power plants. Conceptually, I expand the framework in Eeckhout et al. (2010), which focuses on crackdowns that increase monitoring intensity but assume consistently strong enforcement. China's environmental inspection also enhances the enforcement capabilities of the local bureaucrats by temporarily bridging the authority gap, as the higher authority is present and oversees the cleanup efforts. The short-lived reduction in emissions shows that the inspection program is ineffective at permanently enhancing the capabilities of local bureaucrats. Future research may involve conducting qualitative interviews with environmental protection bureau officials and polluting industry managers to understand how to close the capability gap.

By differentiating among firms' ownership and oversight ties within China's governing hierarchy, I present empirical proof of the "central SOE problem" (Eaton and Kostka, 2017), which was previously backed by anecdotal evidence and correlations. Although large state-owned enterprises are among those most likely to comply with national pollution standards (Li and Chan, 2016), my finding explains the reasoning behind it. In the coal power plant industry, upper state-owned firms are more likely to install pollution control equipment (in this case, SO_2 scrubbers). Nonetheless, they can also easily avoid operating them due to the hierarchical norms that shield these outranking firms from persistent cleanup pressure. Even though ground-level monitor readings are a good proxy for plant emission concentration, they can be influenced by other nearby polluting sources. Future research may utilize other data sources, such as readings from CEMS equipment that released hourly, pollutant-specific concentration data on polluters' exhaust stacks.

5.1.2 Implications for policy

The transient nature of the environmental inspections suggests that one-time shock in monitoring and enforcement can not produce a long-lasting change in behavior among local bureaucrats and polluters. To influence the policy implementation gap at the local level, central authorities may need to sustain cleanup pressure by constructing the capacity to continuously monitor environmental quality and by adjusting local enforcement incentives to place a greater emphasis on environmental quality in local government evaluations. Given that rotating inspections are expensive and difficult to organize under the multi-level governance structure, I propose that the central government may need to establish a national-level monitoring network that collects adequate and accurate information for law enforcement in order to rectify the information asymmetry between the central and local governments. The monitoring network should go beyond ground-level sensors and self-reported data. Mu et al. (2021) finds that local governments in the United States strategically shut down pollution monitors when they foresee a drop in air quality. Karplus et al. (2018) also finds discrepancies between self-reported firm-level measurements and satellite data To expand the surveillance capacity of the monitoring network, I suggest that the Chinese central government may consider conducting geometric imputation or incorporating remote-sensing technology.

This study also shed light on how to regulate the usage of control properties for pollutants at the plant level. Since firms are only required to meet annual reduction targets in SO_2 (usually 8-10% reductions over five years, relative to historical averages) and continual operation is not compulsory, firms may switch off scrubber due to its high operating cost. During the inspection, I find evidence that plants reduce pollution by operating scrubbers. However, once the central pressure leaves the locality, plants reduce scrubber operation. By turning off their scrubbers, companies with a higher ranking than the local government revert to their previous polluting practices more rapidly than municipal entities. Since it is relatively easy and profitable for polluters to cheat by turning off scrubbers, to ensure firms implement a long-term solution to curb pollution, I recommend that the central government may need to undertake continuous scrutiny of firms outside of the inspection periods and focus its attention on outranking firms.

5.2 Effect of citizen complaints on polluter response

Chapter 3 of this dissertation investigates the effectiveness of another approach to strengthening enforcement, namely civic engagement. I ask whether engaging citizens can encourage local bureaucrats and polluting firm managers to increase compliance on an ongoing basis. I build a novel data set that includes all complaint entries filed by citizens during both rounds of the environmental inspections. Using topic modeling, I identify the primary environmental concerns of citizens, who are mostly concerned about air pollution and industrial facilities. Using the quasi-random timing of citizen complaints in an event-study design and comparing firms receiving complaints to those that do not, I find that citizen reporting does not result in a statistically significant reduction in pollutant emissions. After the conclusion of inspections, plants outranking local government revert to their baseline pollution levels more rapidly. Disciplinary actions against polluting plants and associated personnel, such as rectification and holding officials accountable, have little permanent impact on polluter conducts.

By comparing firm responses during the lookback round to the original round, I show that there is no significant effects of central scrutiny on plant pollution during the onsite period and a positive increase in the post-period. This is consistent with my finding in Chapter 2. If the central government does not resolve the problem of information asymmetry and change the perverse incentive structure, top-down scrutiny can not boost local bureaucracy accountability. By dispatching inspection teams directly to outranking firms in the lookback round, I find that upper SOEs revert to pre-inspection levels more slowly than city SOEs after the inspections end. This shows that the solution to the "central SOE problem" may be to focus direct central attention towards outranking firms.

5.2.1 Implications for research

Previous research in the U.S. context demonstrates that concerned individuals may influence polluter behavior (Huet-Vaughn et al., 2018), adding to existing findings that stakeholder pressure can result in permanent environmental changes at the plant level (Kagan et al., 2003). Evidence on the effectiveness of similar Chinese citizen empowerment programs is mixed and mostly qualitative.[2] This chapter provides the first large-N empirical evidence on the incremental effectiveness of citizen complaints on the environmental performance of power plants. Due to the fact that the complaint database includes all pollutant types and polluting industries, future study may examine the environmental impact of citizen complaints against other types of polluters, such as the iron and steel industries.

[2] Hsu et al. (2020) and Mertha (2010) find suggestive evidence of "rights consciousness" when citizens actively participate in such "naming and shaming" initiatives to advance their social justice issues. In contrast, Kostka and Zhang (2018) and Shin (2018) highlight the limitations of such initiatives in China due to low participation and the absence of sanctions. Wang (2018) even characterizes it as a political gambit for the central government to manufacture "symbolic legitimacy".

This chapter also discusses why China's authoritarian leadership has involved citizens in environmental inspections. China is an important case to study because it differs from developed democracies in which citizens can press for accountability to environmental laws through protests, voting, and the court system. Most prior scholarship has focused on these settings (Beierle, 2010; Kagan et al., 2003). In China, statutory and informal procedures for filing complaints against polluters are more limited and must typically be sanctioned by the state. This highlights the problem of how authoritarian governments promote transparency and facilitate bottom-up monitoring in the creation and implementation of environmental policy. Future research may compare the contexts of China with the United States, where there is documented evidence that concerned citizens influence polluter conduct (Huet-Vaughn et al., 2018), and identify the constraints of authoritarian environmental governance.

5.2.2 Implications for policy

This chapter sheds light on the role of citizens participation in authoritarian environmental inspections. Theoretically, citizen reporting should help enhance the state's monitoring capabilities during inspections. However, there is no evidence that citizen complaints increase the effectiveness of enforcement actions. Given that local environmental bureaucrats found the complaint channel to be very taxing (Zhihu, 2017), I suggest that the central state may consider building functional permanent feedback channels that improve transparency and encourage participation. Through a continuous monitoring network, the central government may be able to lessen the labor-intensive aspect of discovering violations. Citizen welfare cannot be maximized by involving citizens in reporting firms' polluting activities when there is already a top-down enforcement effort.

Even if the environmental inspection is short-lived or ineffectual in practice, the central government may gain the legitimacy benefits of enhanced views of its responsiveness. However, accommodating the temporary increase in bureaucratic activity necessitated by this program was incredibly demanding on local environmental bureaus. In contrast, intensifying and institutionalizing citizen scrutiny over a longer period of time, against the backdrop of heightened enforcement, may aid in the long-term improvement of local environmental quality.

5.3 Understanding drivers of citizen complaints

In Chapter 4 of this thesis, I test for evidence of the following factors affecting participation rate: access to pollution information, quality of life, government efficiency, and baseline pollution level. Exploring regional differences at the level of prefecture city, I run regression analysis to determine how these variables affect participation, measured as per-capita complaints received. Cities with better pollution information disclosure systems receive fewer complaints across all pollutant categories. Better access to health care and education is unrelated to the amount of complaints received within a city. So do the efficiency of city government employees. Cities with poor baseline environmental performance receive more complaints per capita. In addition, I use a logit model to examine factors that predict citizen complaints and to determine if citizens can correctly identify firms with poor environmental performance. A higher per-capita income level positively indicates that a complaint will be filed. A high baseline SO_2 does not predict a complaint, and neither does ownership type and oversight level.

I also describe the relationship between historical interaction and present participation. "Informed disenchantment" (Gallagher, 2006) and "deliberate disengagement" (Croke et al., 2016) both cast citizens' political involvement as path-dependent. In other words, individual's propensity to participate in future civic activities is influenced by their perceptions of the effectiveness of engagement, which are formed by their interactions with local bureaucrats in the past. I test if the same situation holds for environmental governance: when citizens realize community monitoring is futile, do they cease using these reporting channels? I exploit a natural experiment as the same monitoring program is reintroduced in the lookback round of nationwide inspections. During the lookback round, I observe a decrease in air-related complaints in cities with higher levels of reversion to baseline pollution after the original inspection round.

5.3.1 Implications for research

Given the limited accessible data and absence of qualitative observations to analyze individual-level change, as previously noted, all empirical analyses in this chapter provide only a correlational/directional explanation rather than a causal explanation. For future study, I believe a field experiment might help elucidate individual preferences about filing a complaint. Because the program is rotational, it is possible to follow the perceptual and behavior changes of randomly selected participants. Prior to the visit of the central inspection team, I should conduct a survey to document individuals' perceptions of the openness and responsiveness of local environmental protection agencies, as well as their willingness to voice environmental concerns and relevant matrices measuring their internal efficacy. I then track if any of the selected experiment participants submitted a complaint during the environmental inspections. For those that filed complaints, I will track the local government's response and the environmental performance of the associated plants.[3] After the inspection team's departure, I will re-administer the survey and record citizens' perceptions of government openness, responsiveness, internal efficacy, and desire to voice concerns. I also record their perception of the overall effectiveness of the program. Comparing the changes in respondents' perceptions between the two polls can help us understand the process driving individual-level political behavior change.

5.3.2 Implications for policy

This chapter discusses a possible challenge with citizen reporting if the central state wants to utilize it as a tool to expand state capacity to detect violations and gather information about local environmental concerns. Citizens are able to distinguish the

[3]The continuous emission monitoring system (CEMS) provides firm-level emission data for large polluters within each locality. It records hourly ambient pollutant concentration data at the firm level, and pollution concentration data is automatically generated by a monitoring device positioned at the end of the pipe. Firms in the CEMS database are major polluters, including power plants, iron/steel factories, and cement plants.

overall environmental wellness of the city, but have difficulty identifying particular polluters. The central government should view citizen complaints as a signal of their dissatisfaction with the environmental condition in nearby communities. However, it can not be used as an information-gathering tool to produce reliable reports on polluter behavior due to the knowledge-intensive nature of detecting air pollution.[4]

Citizens' enthusiasm to participate in environmental monitoring programs decreases as they discover that their complaints do not lead to consistent behavior change for local bureaucrats and plant managers. In the long run, when citizens recognize the ineffectiveness of environmental inspection contrary to the declared objective, the central state may confront more significant threats to regime stability. Complaint channels no longer provide citizens agency, and governments' unresponsiveness may encourage citizens to participate in collective actions or mobilizations.

5.4 Cross-cutting insights and future directions

In this section, I will integrate the findings of individual chapters to highlight implications for future research and policy.

China's environmental inspection is ineffective in bridging the local policy implementation gap. This temporary accountability shock only results in a sharp, short-lived reduction in SO_2 pollution when higher authority is present and paying attention. For such a program to increase long-run enforcement by local environmental protection bureaucrats, the central governments may need to address the three challenges within the principal-agent framework. First, in order to amend the information asymmetry between the central state and local bureaucrats, it may be necessary to establish an extensive monitoring network that provides ongoing scrutiny of firms outside the inspection period. Second, in order to align the incentives of local bureaucrats with those of the central authorities, it may be needed to incorporate hard targets of environmental performance into China's cadre performance evaluation sys-

[4]Multiple complaints were lodged against thermal power facilities by residents who confused water vapor for exhaust gas.

tem. Third, in order to overcome the multi-tasking problems encountered by the local bureaucrats, environmental goals should be designed across contractable dimensions while keeping in mind the possibility of statistical data manipulation.[5]

Although initially, citizens may view the inspection teams' presence and public announcements of how complaints were addressed as an indication of central government's responsiveness in preventing local excesses. As individuals comprehend the ineffectiveness of environmental inspection in improving environmental quality over the long run, I observe a decline in participation rates. Moreover, Van der Kamp (2021) documents that in localities with insufficient bureaucratic accountability, authorities even resort to "blunt force" solutions to control pollution, at the expense of local economic growth and employment. I argue that the central state no longer receives legitimacy benefits from environmental inspections because citizens may perceive them as "performative responsiveness" (Ding, 2020).

Given the limitations of bureaucratic accountability, one option may be to promote citizen monitoring from the bottom up. However, there is a lack of institutionalized channels for civil society participation in China. Developing independent legal institutions that increase openness, together with promoting public monitoring and limited legal actions, may contribute to the long-term improvement of the local environmental quality.

[5]For example, He et al. (2020) find evidence that, in order to achieve water quality objectives, local officials prioritize "water quality readings" over "actual water quality".

Appendix A

Tables

Table A.1: 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:					
log(per capita)	-0.1000**	-0.105	0.0381	0.0133	0.153*
	(-3.10)	(-1.33)	(0.57)	(0.18)	(2.21)
log(pop density)	0.000624	-0.0818*	-0.0279	0.0572	0.0519
	(0.04)	(-2.05)	(-0.82)	(1.55)	(1.47)
log(capital investment)	0.0259	-0.0379	0.0217	0.0106	-0.0202
	(1.29)	(-0.77)	(0.52)	(0.23)	(-0.47)
log(electricity usage)	0.0269	0.0505	-0.00200	-0.0669	-0.00855
	(1.78)	(1.38)	(-0.06)	(-1.96)	(-0.26)
log(SO_2 emission)	-0.0108	0.00145	0.0260	0.0111	-0.0278
	(-0.68)	(0.04)	(0.80)	(0.31)	(-0.82)
log(dust emission)	0.0407*	0.00570	-0.104**	0.0831*	-0.0255
	(2.53)	(0.15)	(-3.12)	(2.29)	(-0.74)
Announce SO_2 ($\mu g/m^3$)	-0.000345	-0.00211	0.000201	0.00300	-0.000744
	(-0.17)	(-0.43)	(0.05)	(0.66)	(-0.17)
Baseline SO_2 ($\mu g/m^3$)	-0.000557	0.00231	0.000544	-0.00353	0.00123
	(-0.27)	(0.46)	(0.13)	(-0.75)	(0.28)
Observations	279	279	279	279	279
R-squared	0.087	0.039	0.048	0.044	0.049
Logit model:					
log(per capita)	-3.497**	-0.515	0.231	0.0680	0.902*
	(-2.93)	(-1.37)	(0.54)	(0.16)	(2.11)
log(pop density)	0.225	-0.377*	-0.173	0.352	0.333
	(0.36)	(-2.01)	(-0.82)	(1.58)	(1.46)
log(capital investment)	0.699	-0.177	0.146	0.0498	-0.129
	(0.98)	(-0.76)	(0.52)	(0.19)	(-0.49)
log(electricity usage)	0.704	0.234	-0.0270	-0.403*	-0.0654
	(1.29)	(1.32)	(-0.14)	(-2.07)	(-0.32)
log(SO_2 emission)	-0.334	0.00673	0.170	0.102	-0.143
	(-0.45)	(0.04)	(0.84)	(0.41)	(-0.72)
log(dust emission)	1.642*	0.0385	-0.654**	0.503*	-0.132
	(2.57)	(0.20)	(-3.01)	(2.22)	(-0.63)
Announce SO_2 ($\mu g/m^3$)	-0.0385	-0.00937	-0.0000371	0.0149	-0.00614
	(-0.80)	(-0.41)	(-0.00)	(0.60)	(-0.20)
Baseline SO_2 ($\mu g/m^3$)	-0.00290	0.0107	0.00458	-0.0189	0.00818
	(-0.05)	(0.45)	(0.15)	(-0.75)	(0.28)
Observations	279	279	279	279	279
Pseudo R-squared	0.309	0.032	0.048	0.043	0.045

Notes: Compares within-round using the 31-province sample. Announce SO_2 corresponds to the average SO_2 concentration in a city 1 to 4 weeks prior. Baseline SO_2 corresponds to the average SO_2 concentration in a city 5 to 10 weeks prior. t-statistics are shown in parentheses.

Table A.2: Difference-in-means and t-test statistics between plants in treated and control cities in the eight-province original sample (before entropy balancing).

	(1) Round 1	(2) Round 2	(3) Round 3
log(per capita)	0.443***	-0.500***	0.606***
	(0.0463)	(0.0460)	(0.0300)
log(pop density)	0.936***	-0.722***	0.674***
	(0.0874)	(0.0516)	(0.0272)
log(capital investment)	0.472***	-0.250***	0.701***
	(0.0932)	(0.0532)	(0.0373)
log(electricity usage)	0.928***	-1.473***	1.403***
	(0.126)	(0.119)	(0.0603)
log(SO_2 emission)	0.129	0.484***	0.115**
	(0.0790)	(0.0678)	(0.0403)
log(distance to center)	-0.280**	0.310***	-0.0475
	(0.0993)	(0.0930)	(0.0739)
log(company age)	0.00110	-0.000435	-0.000422
	(0.000754)	(0.000749)	(0.000631)
revenue share city	0.00580	0.00180	-0.00732
	(0.00451)	(0.0106)	(0.00666)
Upper SOE	-0.123**	0.286***	-0.350***
	(0.0438)	(0.0462)	(0.0341)
Lower SOE	-0.0205	-0.0907**	0.108***
	(0.0357)	(0.0315)	(0.0286)
Observations	468	418	840

Notes: t-statistics are shown in parentheses.

Table A.3: Difference-in-means and t-test statistics between plants in treated and control cities in the eight-province entropy-balanced sample.

	(1) Round 1	(2) Round 2	(3) Round 3
log(per capita)	-0.0000321	0.0373	-0.579***
	(-0.00)	(0.57)	(-9.98)
log(pop density)	-0.00000626	0.0811	-0.398**
	(-0.00)	(1.30)	(-2.75)
log(capital investment)	-0.00000814	-0.00149	-0.340**
	(-0.00)	(-0.02)	(-2.72)
log(electricity usage)	-0.00000638	0.0222	-0.244***
	(-0.00)	(0.86)	(-3.78)
log(SO_2 emission)	-0.00000561	-0.0301	-0.00190
	(-0.00)	(-0.67)	(-0.02)
log(distance to center)	-0.000000286	-0.00871	-0.00893
	(-0.00)	(-0.16)	(-0.25)
log(company age)	-0.000195	0.00483	0.820
	(-0.00)	(0.00)	(0.18)
revenue share city	-0.000000352	-0.0750	0.0554
	(-0.00)	(-0.14)	(0.17)
Upper SOE	0.00000211	-0.0276	0.260***
	(0.00)	(-0.30)	(3.59)
Lower SOE	-0.00000872	0.0104	-0.241*
	(-0.00)	(0.10)	(-2.41)
Observations	468	418	840

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.

Table A.4: Event study coefficients during baseline weeks.

	Original (1) log(SO_2)	**Entropy-Balanced** (2) log(SO_2)
Never-treated:		
Baseline (-10 wks)	0.075	0.191*
	(0.081)	(0.080)
Baseline (-9 wks)	-0.054*	0.086
	(0.022)	(0.037)
Baseline (-8 wks)	0.007	0.169
	(0.025)	(0.129)
Baseline (-7 wks)	0.032	0.140*
	(0.078)	(0.050)
Baseline (-6 wks)	0.008	0.053
	(0.031)	(0.053)
Observations	17,221	13,273
R-squared	0.597	0.637
All:		
Baseline (-10 wks)	0.018	0.011
	(0.074)	(0.062)
Baseline (-9 wks)	-0.001	0.015
	(0.087)	(0.155)
Baseline (-8 wks)	0.096	0.061
	(0.072)	(0.066)
Baseline (-7 wks)	0.088	0.095
	(0.053)	(0.052)
Baseline (-6 wks)	-0.049	-0.063
	(0.069)	(0.085)
Observations	46,991	33,474
R-squared	0.578	0.627
Already-treated:		
Baseline (-10 wks)	-0.075	-0.249**
	(0.118)	(0.064)
Baseline (-9 wks)	0.165	-0.097
	(0.177)	(0.168)
Baseline (-8 wks)	0.059	-0.156
	(0.132)	(0.068)
Baseline (-7 wks)	0.077	-0.137
	(0.044)	(0.093)
Baseline (-6 wks)	-0.165	-0.336
	(0.111)	(0.148)
Observations	35,050	24,907
R-squared	0.658	0.685
Plant FE	Yes	Yes
Year FE	Yes	Yes
Week FE	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 -5). 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 A.5: Direct effect of campaign with interactions on scrubber technology in different post periods by plant oversight.

	All	Central SOE	Provincial SOE	Lower SOE	Private
	(1) $\log(NO_X)$	(2) $\log(NO_X)$	(3) $\log(NO_X)$	(4) $\log(NO_X)$	(5) $\log(NO_X)$
Announcement	0.000	-0.019	-0.004	-0.074	0.021
	(0.026)	(0.039)	(0.042)	(0.048)	(0.030)
On-site	0.046	0.027	0.046	-0.138	0.102**
	(0.046)	(0.056)	(0.068)	(0.099)	(0.050)
Post 1-5 wks	-0.039	-0.105	-0.081	-0.125*	-0.006
	(0.042)	(0.069)	(0.067)	(0.070)	(0.042)
Post 6-10 wks	0.061	0.051	0.072	0.011	0.058
	(0.038)	(0.069)	(0.059)	(0.052)	(0.046)
On-site$\times$ SO_2 Scrub	-0.071*	-0.055	-0.041	0.002	-0.122**
	(0.036)	(0.047)	(0.067)	(0.102)	(0.053)
Post 1-5 wks$\times$ SO_2 Scrub	0.064	0.129**	0.185**	0.027	0.016
	(0.039)	(0.061)	(0.086)	(0.080)	(0.039)
Post 6-10 wks $\times$ SO_2 Scrub	0.037	0.064	0.097	-0.056	0.027
	(0.040)	(0.078)	(0.075)	(0.068)	(0.045)
Observations	24,292	2,401	4,160	3,639	13,584
R-squared	0.785	0.770	0.794	0.821	0.801
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. Column (2) includes only central SOE firms (state-owned enterprises with national-level or provincial-level oversight). Column (3) includes only upper SOE firms (state-owned enterprises with national-level or provincial-level oversight). Column (4) includes only firms that are lower SOE (state-owned enterprises with city-level or county-level oversight). Column (5) 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. 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.

Table A.6: Effect of inspections with interactions on scrubber technology in different post period by plant capacity (MW).

	All	Cap $\leq$ 50	50 $<$ Cap $\leq$ 500	Cap $>$500
	(1) $\log(NO_X)$	(2) $\log(NO_X)$	(3) $\log(NO_X)$	(4) $\log(NO_X)$
Announcement	0.000	0.011	-0.029	0.018
	(0.026)	(0.032)	(0.031)	(0.055)
On-site	0.046	0.049	0.048	-0.041
	(0.046)	(0.052)	(0.054)	(0.082)
Post 1-5 wks	-0.039	-0.052	-0.009	-0.018
	(0.042)	(0.048)	(0.049)	(0.087)
Post 6-10 wks	0.061	0.058	0.066	0.100
	(0.038)	(0.040)	(0.059)	(0.107)
On-site× SO_2 Scrub	-0.071*	-0.078	-0.066	0.017
	(0.036)	(0.057)	(0.046)	(0.067)
Post 1-5 wks× SO_2 Scrub	0.064	0.064	0.047	0.052
	(0.039)	(0.067)	(0.042)	(0.090)
Post 6-10 wks× SO_2 Scrub	0.037	0.032	0.038	0.044
	(0.040)	(0.059)	(0.055)	(0.086)
Observations	44,502	29,906	11,373	3,223
R-squared	0.798	0.804	0.776	0.818
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 $\leq$ 50 MW. Column (3) includes only firms with electricity production capacity $>$ 50 MW and $\leq$ 500 MW. Column (4) includes only firms with electricity production capacity $>$ 500 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. 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.

Table A.7: Example of one complaint entry recorded for Xianning, Hubei Province.

(a) Chinese version.

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。

(b) English 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 4th and 5th, 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.

Table A.8: 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.9: Direct effect of the inspections with interactions on plants being shutdown in the look back round.

	(1) $\log(SO_2)$	(2) $\log(SO_2)$	(3) $\log(SO_2)$	(4) $\log(SO_2)$
Announce	-0.013	-0.013	-0.013	-0.013
	(0.048)	(0.048)	(0.048)	(0.048)
On-site	-0.032	-0.031	-0.032	-0.032
	(0.039)	(0.039)	(0.039)	(0.039)
Post	0.109*	0.109*	0.109*	0.109*
	(0.061)	(0.061)	(0.061)	(0.061)
Announce × Shutdown	-0.138**			
	(0.063)			
On-site× Shutdown		-0.104***		
		(0.034)		
Post× Shutdown			-0.295***	-0.220***
			(0.064)	(0.058)
Post× Shutdown× Upper SOE				-0.152*
				(0.079)
Observations	45,802	45,802	45,802	45,802
R-squared	0.689	0.689	0.689	0.689
Number of plants	446	446	446	446
Plant FE	Yes	Yes	Yes	Yes
Year FE	Yes	Yes	Yes	Yes
Week FE	Yes	Yes	Yes	Yes

Notes: Sample used in this table are limited to plants received a complaint during the inspection period. 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.

Table A.10: Interaction effects between indices measuring level of pollution information transparency and disclosure and baseline SO_2 pollution level.

	Total	Air	Water	Soil	Noise	Ecology	Other
Daily violation#baseline_SO_2	0.145*	0.116**	0.0231	0.0252	0.0343	0.0213	0.0110
	(0.0790)	(0.0473)	(0.0281)	(0.0168)	(0.0321)	(0.0269)	(0.0202)
Environ perform#baseline_SO_2	-0.832	-0.620**	-0.252	-0.204*	-0.218	-0.163	-0.347**
	(0.514)	(0.307)	(0.183)	(0.109)	(0.209)	(0.175)	(0.131)
Autom monitoring#baseline_SO_2	-0.279**	-0.166**	-0.0662*	-0.0514**	-0.103**	-0.0404	-0.0122
	(0.111)	(0.0665)	(0.0396)	(0.0236)	(0.0452)	(0.0378)	(0.0283)
Complaints & rep#baseline_SO_2	0.0490	0.0372	-0.0134	0.00507	-0.00181	-0.0990	-0.00930
	(0.193)	(0.116)	(0.0689)	(0.0411)	(0.0787)	(0.0657)	(0.0493)
Emis of key ent#baseline_SO_2	-0.0867	-0.0282	-0.00487	-0.0375	-0.0168	-0.0134	0.0270
	(0.162)	(0.0967)	(0.0575)	(0.0343)	(0.0657)	(0.0549)	(0.0412)
EIA#baseline_SO_2	0.281*	0.153	0.0350	0.0812**	0.0736	0.0718	-0.0112
	(0.154)	(0.0923)	(0.0549)	(0.0327)	(0.0627)	(0.0524)	(0.0393)
Observations	67	67	67	67	67	67	67
R-squared	0.381	0.432	0.221	0.385	0.236	0.232	0.238

Table A.11: Interaction effects between indices measuring local quality of life and baseline SO2 pollution level.

	Total	Air	Water	Soil	Noise	Ecology	Other
Ind waste disp (%)#baseline_SO_2	-0.0751	-0.0399	-0.0195	-0.0157*	-0.0284	-0.0243	-0.00556
	(0.0465)	(0.0286)	(0.0173)	(0.00908)	(0.0187)	(0.0161)	(0.0125)
Per capita green (m^2)#baseline_SO_2	0.133	0.0843	0.0265	0.0439***	0.0331	0.0147	0.0434*
	(0.0825)	(0.0507)	(0.0306)	(0.0161)	(0.0332)	(0.0285)	(0.0222)
Better air quality (%)#baseline_SO_2	-0.0191	-0.0123	-0.00540	-0.00631	-0.00996	2.01e-05	-0.00280
	(0.0355)	(0.0218)	(0.0132)	(0.00692)	(0.0143)	(0.0122)	(0.00957)
Infant mort (per 1000)#baseline_SO_2	0.163	0.0492	0.0270	0.0288	0.0801	0.0542	0.00225
	(0.133)	(0.0818)	(0.0494)	(0.0260)	(0.0536)	(0.0459)	(0.0359)
Workers health ins (%)#baseline_SO_2	0.0581	0.0283	0.0125	0.0116*	0.0251*	0.0131	0.00567
	(0.0352)	(0.0217)	(0.0131)	(0.00688)	(0.0142)	(0.0122)	(0.00950)
Per capita educ (RMB)#baseline_SO_2	-0.000477	-0.000162	-9.18e-05	-0.000183	-0.000173	-0.000146	4.58e-05
	(0.000628)	(0.000386)	(0.000233)	(0.000123)	(0.000253)	(0.000217)	(0.000169)
Female enroll (%)#baseline_SO_2	0.0847	0.0410	0.0272	0.0333**	0.0342	0.0419	0.0128
	(0.0844)	(0.0519)	(0.0313)	(0.0165)	(0.0340)	(0.0291)	(0.0228)
Annual wage (RMB)#baseline_SO_2	8.50e-06	6.15e-05	-1.83e-05	-3.33e-05	-3.76e-05	-5.93e-05	-4.44e-05
	(0.000164)	(0.000101)	(6.09e-05)	(3.20e-05)	(6.62e-05)	(5.67e-05)	(4.43e-05)
Observations	67	67	67	67	67	67	67
R-squared	0.336	0.352	0.148	0.387	0.211	0.130	0.123

Table A.12: Relationship between 10-week environmental performance change and delta of number of air-related complaints per million people received.

	ΔAir	ΔAir	ΔAir	ΔAir	ΔAir
log(per capita)	8.745	9.109	9.767	9.357	10.80
	(8.093)	(8.237)	(8.148)	(8.199)	(8.051)
log(fixed asset inv)	4.611	2.756	3.678	3.359	3.587
	(4.987)	(4.992)	(4.962)	(4.997)	(4.873)
log(elec usage)	-3.505	-4.120	-4.270	-4.223	-4.579
	(3.550)	(3.616)	(3.547)	(3.573)	(3.497)
log(annual SO_2 emi)	0.956	2.505	2.209	2.095	2.056
	(4.501)	(4.566)	(4.486)	(4.519)	(4.423)
log(annual dust emi)	-0.00565	1.250	0.403	0.885	0.642
	(3.666)	(3.738)	(3.670)	(3.686)	(3.569)
Rever SO_2	-0.441**				
	(0.205)				
Rever NO_X		-0.132			
		(0.236)			
Rever PM_{25}			-0.232*		
			(0.128)		
Rever PM_{10}				-0.118	
				(0.0954)	
Rever AQI					-0.320***
					(0.122)
Observations	130	130	130	130	130
R-squared	0.063	0.030	0.053	0.040	0.080

Table A.13: Relationship between 10-week environmental performance change and delta of number of non air-related complaints per million people received.

	ΔNonair	ΔNonair	ΔNonair	ΔNonair	ΔNonair
log(per capita)	10.78**	10.89**	10.70*	10.84**	10.19*
	(5.399)	(5.423)	(5.424)	(5.425)	(5.397)
log(fixed asset inv)	-8.484**	-9.067***	-9.287***	-9.120***	-9.436***
	(3.327)	(3.286)	(3.303)	(3.307)	(3.267)
log(elec usage)	0.194	-0.00381	-0.0948	-0.0813	-0.000161
	(2.368)	(2.380)	(2.361)	(2.364)	(2.344)
log(annual SO_2 emi)	-3.349	-2.870	-2.946	-2.946	-2.887
	(3.003)	(3.006)	(2.986)	(2.990)	(2.965)
log(annual dust emi)	0.839	1.242	1.627	1.410	1.776
	(2.446)	(2.461)	(2.443)	(2.439)	(2.393)
Rever SO_2	-0.138				
	(0.137)				
Rever NO_X		-0.0386			
		(0.155)			
Rever PM_{25}			0.0429		
			(0.0852)		
Rever PM_{10}				0.00390	
				(0.0631)	
Rever AQI					0.116
					(0.0816)
Observations	130	130	130	130	130
R-squared	0.088	0.081	0.082	0.081	0.095

Table A.14: Relationship between 12-month environmental performance change and delta of number of air-related complaints per million people received.

	ΔAir	ΔAir	ΔAir	ΔAir	ΔAir
log(per capita)	-9.370	-10.84	-8.431	-8.965	-8.560
	(8.175)	(8.005)	(7.957)	(8.114)	(8.122)
log(fixed asset inv)	-1.948	-0.829	-3.198	-1.504	-2.512
	(4.973)	(4.876)	(4.824)	(4.950)	(4.920)
log(elec usage)	4.313	4.788	4.387	4.630	4.424
	(3.561)	(3.481)	(3.467)	(3.539)	(3.539)
log(annual SO_2 emi)	-1.124	-0.493	-0.533	-1.915	-1.415
	(4.566)	(4.440)	(4.422)	(4.477)	(4.496)
log(annual dust emi)	-2.106	-2.249	-2.161	-2.400	-2.108
	(3.620)	(3.531)	(3.519)	(3.603)	(3.594)
Rever SO_2	-0.818				
	(0.549)				
Rever NO_X		-0.787***			
		(0.273)			
Rever PM_{25}			-0.632***		
			(0.210)		
Rever PM_{10}				-0.203**	
				(0.102)	
Rever AQI					-0.356*
					(0.182)
Observations	130	130	130	130	130
R-squared	0.045	0.089	0.095	0.058	0.057

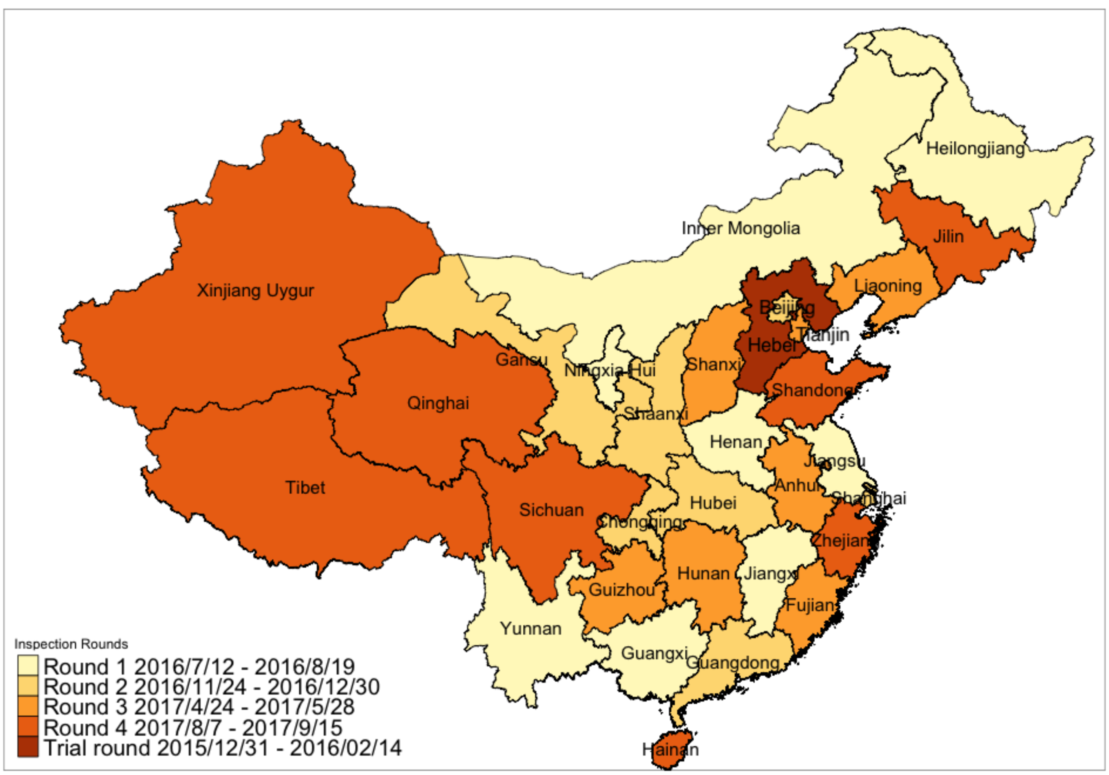
Table A.15: Relationship between 12-month environmental performance change and delta of number of non air-related complaints per million people received.

	ΔNonair	ΔNonair	ΔNonair	ΔNonair	ΔNonair
log(per capita)	10.58*	9.756*	11.15**	10.85**	11.14**
	(5.373)	(5.301)	(5.283)	(5.246)	(5.326)
log(fixed asset inv)	-8.621***	-8.028**	-9.405***	-8.018**	-8.996***
	(3.269)	(3.229)	(3.203)	(3.201)	(3.226)
log(elec usage)	-0.114	0.169	-0.0660	0.168	-0.0367
	(2.341)	(2.305)	(2.302)	(2.288)	(2.321)
log(annual SO_2 emi)	-2.204	-1.932	-1.993	-2.655	-2.367
	(3.001)	(2.940)	(2.936)	(2.894)	(2.948)
log(annual dust emi)	1.126	1.076	1.137	0.750	1.110
	(2.380)	(2.338)	(2.337)	(2.329)	(2.357)
Rever SO_2	-0.552				
	(0.361)				
Rever NO_X		-0.461**			
		(0.181)			
Rever PM_{25}			-0.357**		
			(0.139)		
Rever PM_{10}				-0.190***	
				(0.0658)	
Rever AQI					-0.255**
					(0.120)
Observations	130	130	130	130	130
R-squared	0.098	0.127	0.127	0.139	0.113

Appendix B

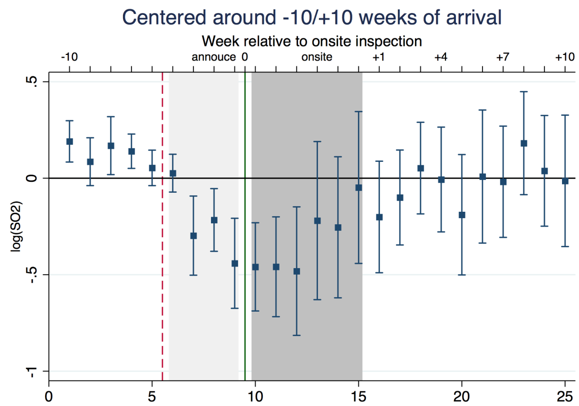
Figures

Figure B-1: Geographical composition and timing of the five inspection batches in the original round.

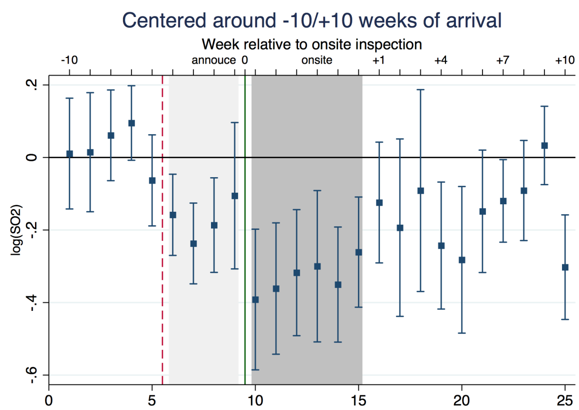


Trial batch includes only Hebei province. Batches 1-4 cover either 7 or 8 provinces, and do not cover Hong Kong, Macau, or Taiwan.

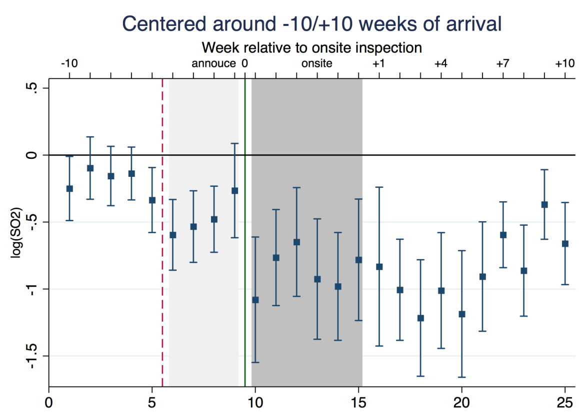
Figure B-2: Event study showing percent change in SO_2 for each week relative to a reference week



(a) Never-treated



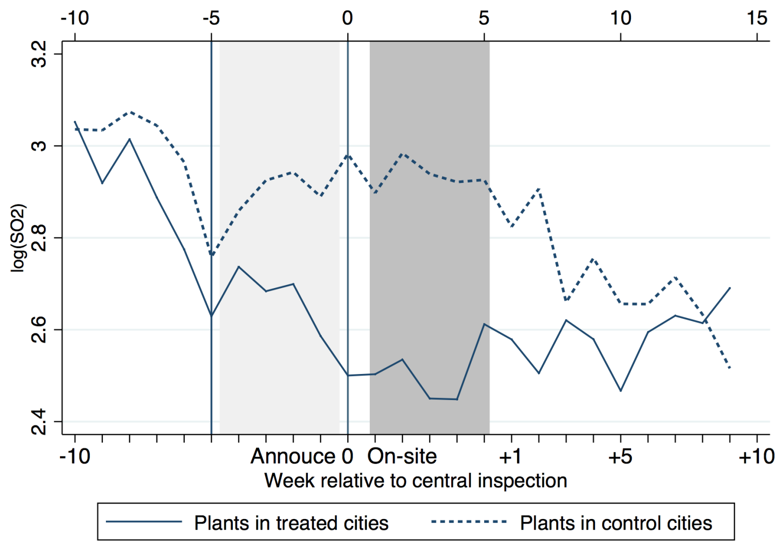
(b) All



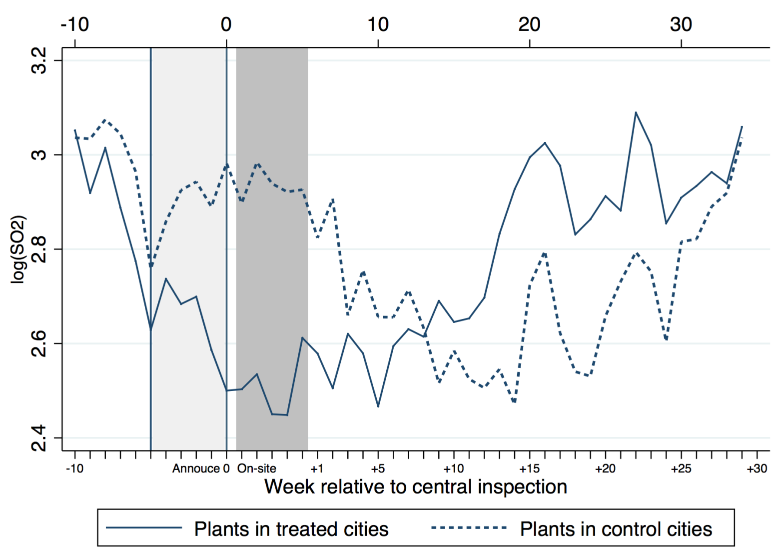
(c) Already-treated

The reference week is defined as the week before a crackdown in announced (denoted by week -5). The graph is centered on the Announce and On-site periods of the inspections, with a 10-week post-inspection horizon. Coefficients are at weekly level in the post period.

Figure B-3: Comparison of $\log(SO_2)$ concentrations at plants in treated and control cities around the inspection event window, using data for the eight-province sample



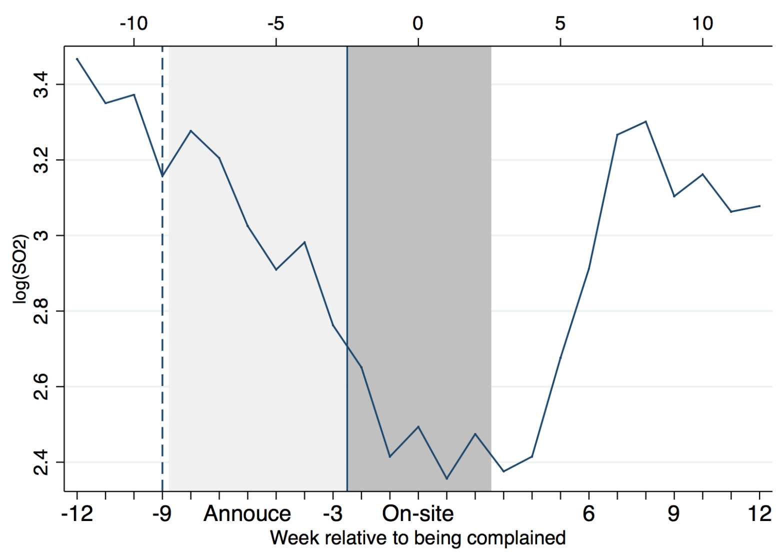
(a) Short-term (up to 10 weeks post inspection)



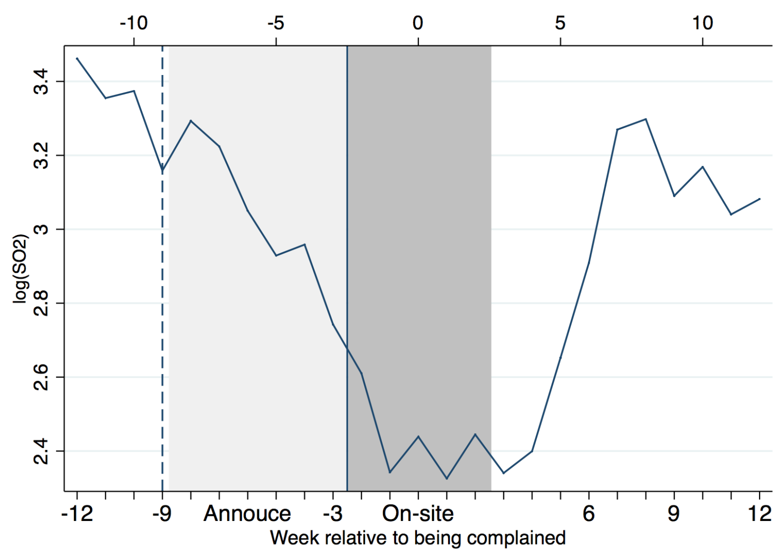
(b) Long-term (up to 30 weeks post inspection)

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 eight 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 B-4: Comparison of log(SO_2) concentrations at power plants during inspections using two different data sources for Henan province.



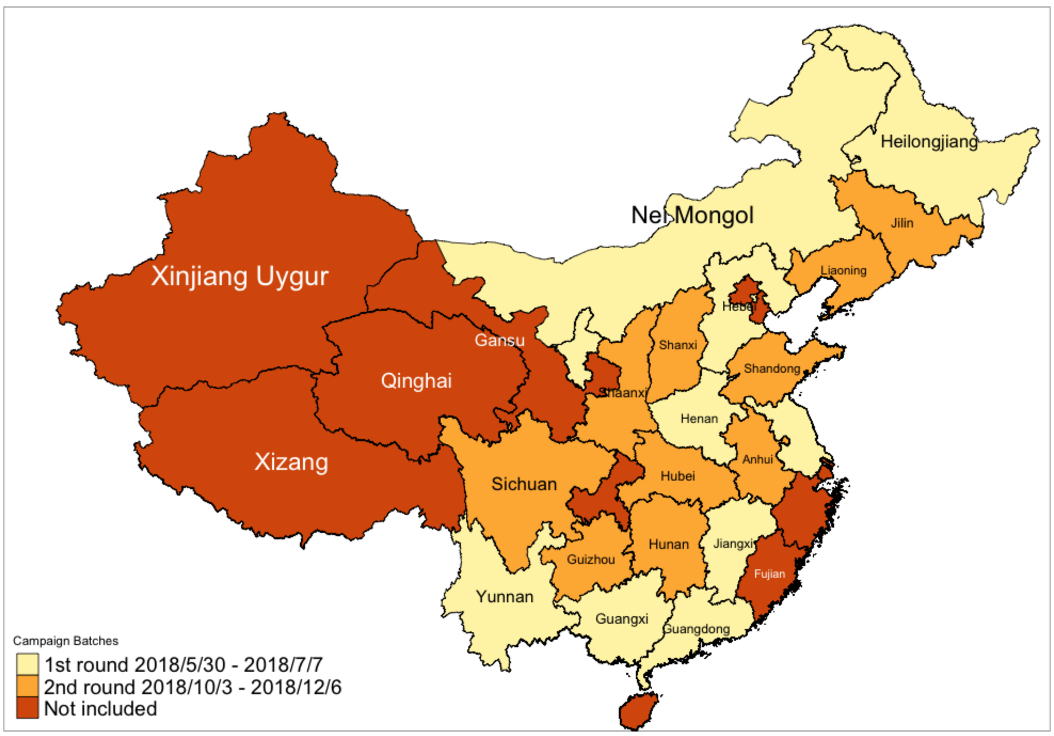
(a) Monitor-level data



(b) CEMS data

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.

Figure B-5: Geographical composition and timing of the two inspection batches in the lookback round.



Each batch covers 10 provincial-level regions.

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