WORKING PAPER · NO. 2022-135

Does the Squeaky Wheel Get More Grease? The Direct and Indirect Effects of Citizen Participation on Environmental Governance in China

Mark Buntaine, Michael Greenstone, Guojun He, Mengdi Liu, Shaoda Wang, and Bing Zhang

OCTOBER 2022

EPIC CHINA
ENERGY POLICY INSTITUTE
AT THE UNIVERSITY OF CHICAGO
芝加哥大学能源与环境政策研究所

An Affiliated Center of
Becker Friedman Institute

5757 S. University Ave.
Chicago, IL 60637
Main: 773.702.5599
bfi.uchicago.edu

Does the Squeaky Wheel Get More Grease? The Direct and Indirect Effects of Citizen Participation on Environmental Governance in China

Mark Buntaine, Michael Greenstone, Guojun He,

Mengdi Liu, Shaoda Wang, and Bing Zhang*

[October 2022]

Abstract

We conducted a nationwide field experiment in China to evaluate the direct and indirect impacts of assigning firms to public or private citizen appeals treatments when they violate pollution standards. There are three main findings. First, public appeals to the regulator through social media substantially reduce violations and pollution emissions, while private appeals cause more modest environmental improvements. Second, experimentally adding "likes" and "shares" to social media appeals increases regulatory effort, suggesting visibility as an important mechanism. Third, treatment pollution reductions are not offset by control firm increases, based on randomly varying the proportion of treatment firms at the prefecture-level.

Keywords: citizen participation, social media, environmental governance

JEL: Q52; P26; P28

*Buntaine: University of California, Santa Barbara; buntaine@bren.ucsb.edu. Greenstone: University of Chicago and NBER; mgreenst@uchicgao.edu. He: University of Hong Kong; gjhe@hku.hk. Liu: University of International Business and Economics; liumengdi@uibe.edu.cn. Wang: University of Chicago and NBER; shaoda@uchicago.edu. Zhang: Nanjing University; zhangb@nju.edu.cn. We thank Martina Bjorkman-Nyqvist, Robin Burgess, Fiona Burlig, Jiahua Che, Hanming Fang, Eyal Frank, Chang-Tai Hsieh, Kelsey Jack, Ruixue Jia, Panle Jia Barwick, Ryan Kellogg, Jing Li, Shanjun Li, Mushfiq Mobarak, Ben Olken, Nancy Qian, James Robinson, Nicholas Ryan, Joseph Shapiro, Reed Walker, Ye Wang, Daniel Xu, David Yang, Noam Yuchtman, and numerous seminar and conference participants for insightful suggestions. The research described in this article was approved by the IRB at the University of Chicago, University of Hong Kong, and University of California, Santa Barbara. Jiaying Chen, Xun Fan, Yue He, Neil Himwich, Chenye Liu, Zifu Liu, Ziyi Liu, Wenwei Peng, Fan Sun, Yue Tang, Fanyu Wang, Xurui Wang, Jiaqi Zhang, Yimeng Zhang and Ziao Zhu provided excellent research assistance. Financial support from the National Science Foundation of China (Grant No. 71825005 & 72161147002) and the Energy Policy Institute at UChicago (EPIC) is gratefully acknowledged. The AEA RCT registry ID is AEARCTR-0005601.

I. Introduction

Across the globe, 2.8 billion people breathe air that is considered hazardous by the World Health Organization and 1.5 billion people contend with polluted water. A rapidly growing literature has documented severe consequences for health (Greenstone et al., 2015; Greenstone and Hanna, 2014; Ebenstein et al., 2017), labor productivity (Graff-Zivin and Neidell, 2012; Chang et al., 2016; Adhvaryu et al., 2016), human capital accumulation (Isen et al., 2017; Ebenstein and Greenstone, 2022), and welfare (Kremer et al. 2011; Currie et al., 2015; Ito and Zhang, 2020; Wang and Wang, 2020). At the same time, most countries have strict standards and regulations on the books. It is apparent that the enforcement of regulations is failing in many parts of the world (Greenstone and Jack, 2015; United Nations Environment Program, 2019), but whether that is by design to facilitate economic growth (Greenstone et al., 2012; He et al., 2020) or due to genuine capacity issues (Duflo et al., 2013 and 2018) is largely unknown.

An increasingly popular tool for reducing pollution is to encourage bottom-up participation in environmental governance. Programs that enable citizens, non-governmental organizations, shareholders, and the media to participate in environmental enforcement date back at least to the 1980s when the United States introduced the Toxics Release Inventory (TRI) that required firms to publicly release their toxic emissions. In the subsequent 35 years, similar programs have been implemented in many countries, including Canada, China, India, and Indonesia.[1] Concurrently, many countries created official channels for the public to report pollution and violations of standards.[2] Yet, there has been little rigorous evidence on whether and how citizens can leverage the government-released information to affect the enforcement of pollution standards and emissions at scale.

Additionally, we are unaware of any evidence on the indirect or general equilibrium impacts of bottom-up participation in environmental governance. In principle, the indirect impacts could reduce

[1] Besides the TRI, specific programs include the Greenhouse Gas Reporting Program (GHGRP) in the US and Canada, the Maharashtra Star Rating Program (MSRP) in India, the Program for Pollution Control, Evaluation, and Rating (PROPER) in Indonesia, and the Continuous Emissions Monitoring System (CEMS) in China.

[2] For example, pollution hotlines and websites to file complaints against pollution violations can be found in countries like the US, the UK, China, Canada, etc.

or even completely undo any direct impacts of citizen participation. Alternatively, it could augment them. The former would happen if citizen complaints about some firms increase regulatory oversight of them but reduces regulatory oversight of other firms. In the latter case, public participation may cause *all* firms to raise their expectations of the costs of violating pollution standards, causing even non-targeted firms to become more vigilant in reducing their emissions.

This paper evaluates the direct and indirect impacts of public participation in the enforcement of environmental standards in China, the world's largest polluter and manufacturer. A compelling feature of the study's context is that the Ministry of Ecology and Environment (MEE) maintains a Continuous Emissions Monitoring System (CEMS) that automatically collects hourly emissions data for 24,620 major polluting plants nationwide. These plants are responsible for more than 75% of China's total industrial emissions. These data are available in real time both to regulators and the public through provincial CEMS websites. Despite the widespread availability of these data, environmental compliance remains imperfect: in 2019, more than 33% of the CEMS firms committed pollution violations.

We conducted an eight-month nationwide field experiment that leveraged the CEMS data to file appeals against firms that violated standards. We randomly assigned each CEMS firm to a control arm or one of several treatment arms which mirror the officially sanctioned ways that citizens and non-governmental organizations already participate in monitoring pollution. The starting point for implementation was the daily determination of the identity of all firms in violation of relevant emissions standards. Specifically, when a treated firm committed a violation, citizen volunteers who cooperated with our experiment filed an appeal through one of two broadly-defined channels: (1) *private appeals* where the citizens complained to the regulator or the firm about the violation in ways that could not be observed by other members of the public; (2) *public appeals* where the citizens complained about the violation on Weibo, a popular Chinese social media platform that is comparable to Twitter. In total, the experiment intervened against nearly 3,000 pollution violations. This form of citizen appeal is a regular occurrence in China; for example, annually there are roughly 300,000 appeals about industrial emissions registered with the Ministry of Environmental Protection by citizens and

NGOs. Importantly, this experiment operated separately from the Government's regulatory efforts, so our estimates are informative of the way that the regulators respond to citizen complaints within existing regulatory practices.

Moreover, following Crépon et al. (2013), we cross-randomized treatment intensity at the prefecture level to assess whether indirect or general equilibrium consequences of appeals would offset their direct or partial equilibrium effects. In 60% of the prefectural cities we assigned 95% of the CEMS firms to treatment arms, while in the remaining 40% of prefectural cities, we assigned 70% of the firms to treatments. Besides the direct effect on violators in the treatment group, the treatment could influence the behavior of treatment group firms that do not violate standards and the entire control group. On the one hand, if firms believe regulatory effort is zero sum due to limited capacity, then the firms that were not targeted may increase emissions. On the other hand, if *all firms* in the 95% prefectures believe that regulatory oversight has generically increased, relative to firms in the 70% prefectures, then even firms that were not targeted will reduce their emissions. Whether one of these forces dominates is ultimately an empirical question.

There are three primary findings. First, public appeals on social media significantly reduced firms' subsequent violations and emissions, while private appeals to regulators and firms had a more marginal impact. Specifically, the public appeals treatment arm reduced violations by more than 60%, relative to the control group. Additionally, over the 8-month study period the public appeals treatment caused sulfur dioxide (SO_2) emission concentrations to decline by 12.2% and reduced chemical oxygen demand (COD) emission concentrations by 3.7% relative to the control group. In contrast, even when using essentially the same content and wording as the public appeals, private appeals only caused modest improvements in the firms' environmental performance. The violations and emissions reductions were concentrated among the firms that frequently violated the standard prior to the experiment, especially those that significantly exceeded it.

Second, experimentally increasing the visibility of appeals about a violation increases oversight by regulators, highlighting motivated effort as an important mechanism. Specifically, we randomized the visibility of social media appeals about a violation by experimentally adding 10 additional "likes" and "shares" to the Weibo post, which would otherwise obtain 0.66 "likes" and "shares" naturally. This intervention caused regulators to become significantly more responsive; the probability of a reply to appeals increased by 40%, the length of written replies to appeals doubled, and the probability of an onsite investigation jumped by nearly 65%. In contrast, we fail to find evidence of several other potential mechanisms, including that the treatments generated more appeals by other citizens outside of the experiment or that they caused firms to manipulate CEMS data.

Third, across a mix of outcomes, we find that the general equilibrium impacts do not offset the partial equilibrium effects; if anything, the interventions might have created positive spillover effects. For example, the relative probability of a violation was either unchanged or lower among the control and treatment firms in the higher intensity prefectures, although the reduced violation rates are not always statistically significant by conventional criteria. Overall, accounting for both general and partial equilibrium effects, we find that ambient SO_2 concentrations declined by 3.5% in the 95% treatment prefectures (significant at the 10% level) relative to the 70% treatment prefectures (significant at 10% level).

This paper makes four contributions. First, this nationwide experiment allows us to offer unique insights into when and how citizen participation affects governance at scale. While citizen participation has long been promoted as the key to improving government accountability (Stiglitz, 2002; Mansuri and Rao, 2004; World Bank, 2004), the existing literature has found mixed evidence on its effectiveness (Olken, 2007; Banerjee and Duflo, 2006; Björkman and Svensson, 2009; Banerjee et al., 2010; Grossman et al., 2018; Buntaine et al., 2021ab). These previous studies have addressed whether monitoring by citizens can improve governance by providing new, decentralized information about governmental performance. A distinctive feature of our study is that we focus on a setting where the key information is already collected and disclosed by the government itself. It allows us to pin down how bottom-up participation influences government accountability through incentives to be responsive to public demands (without confounding it with the impacts of the increased availability of decentralized information). Moreover, the unprecedented scale of our experiment permits us to vary the publicity, channel, and target of citizen appeals and thereby helps us understand when and why citizen participation affects the enforcement of regulations, at least in the Chinese context. Our paper is also the first to connect citizen participation, regulatory effort, and adjustments by firms, showing how participation can meaningfully decrease pollution.[3]

Second, this paper also relates to the burgeoning literature on social media's political and economic consequences. Existing papers have mostly focused on how social media shapes citizens' political attitudes (Bakshy et al., 2015; Bursztyn et al., 2019; Allcott et al., 2020; Yanagizawa-Drott et al., 2021), and how it can foster collective action, both in China (Chen and Yang, 2019; Qin et al., 2021), as well as in other authoritarian regimes globally (Steinert-Threlkeld 2017; Acemoglu et al., 2018; Zhuravskaya et al., 2020; Enikolopov et al., 2020). Adding to this literature, our paper is the first to experimentally study how citizens can leverage social media to hold governments more accountable in policy enforcement, focusing on both partial equilibrium and general equilibrium consequences of using social media for bottom-up citizen participation in governance.[4]

Third, we add to the literature on the political economy of environment. Existing work in this area has mostly focused on the strategic behavior of politicians in determining and implementing environmental policies (List and Sturm, 2006; Kahn et al., 2015; Jia, 2017, Greenstone et al., 2020), or the strategic interactions among local governments over environmental externalities (Burgess et al., 2012; Lipscomb and Mobarak, 2016; He et al., 2020; Wang and Wang, 2020). In this paper, we provide experimental evidence on how pollution appeals by citizens hold local governments in China accountable in enforcing existing environmental standards. More generally, this paper also relates to the literature on the cost and benefit of different environmental policies (Henderson 1996; Greenstone 2002; Walker 2013; Ryan 2012; Kahn and Mansur 2013): our results demonstrate that mobilizing the

[3] Relatedly, there is also an emerging political science literature on authoritarian responsiveness, which studies the factors that determine whether an authoritarian government replies to citizen's requests (e.g., Chen et al., 2016; Distelhorst and Hou, 2017; Anderson et al., 2019). We add to that literature by showing that the government not only replies to appeals and requests when faced with public pressure, but also takes costly actions that result in actual improvements in government accountability.

[4] In a related paper, Mei and Wu (2022) use observational data to document how social media discussions of a vaccine-related scandal in China led to more transparent procurement of vaccines. Our paper echoes these findings in the context of environmental regulation enforcement, and our experimental design allows us to further compare the effectiveness of social media participation to other channels of citizen participation, as well as investigating the associated general equilibrium effects.

public to engage in monitoring the performance of governments and firms might be a cost-effective way to improve compliance with existing environmental laws.[5]

Fourth, this paper bridges two strands of literature on the political economy of China's local governance model. The existing literature has pointed out that local governments in China have incentives to facilitate growth and provide support to the firms through both formal and informal institutions (Qian and Weingast, 1997; Xu, 2011; Bai et al., 2020); and when dealing with the citizens, Chinese local governments have strong incentives to maintain local stability (Chen, 2012; Lorentzen, 2013; Campante et al., 2019, Qin et al., 2021; Beraja et al., 2021). Our paper connects these two lines of literature by documenting the interactions between the state-citizen relationship and the state-business relationship: when the public gets more involved in China's process of environmental governance, the regulatory relationship between government and polluting firms is reshaped; the result is increased governmental effort and lower pollution emissions by firms. Investigating the interactions between firms, citizens, and the state in a synthesized framework deepens our understanding of China's system for local governance.

The remainder of this paper proceeds as follows. Section II introduces the institutional background. Section III discusses our experiment and data. Section IV presents the main empirical findings, while Section V investigates the underlying mechanisms. Section VI discusses the general equilibrium effects. Section VII concludes.

II. Institutional Background

This section describes the institutional background for the field experiment. Section II.A details the encouragement and development of citizen participation in environmental governance in China. Section II.B discusses China's continuous emissions monitoring system. The section concludes with III.C, summarizing our qualitative learnings about the dynamics between China's citizens,

[5] Relatedly, this paper clarifies the pathways by which transparency and information disclosure affect government and firm behavior. Increasing the amount of information disclosed to the public has become a common policy to improve regulatory and government performance (Gavazza and Lizzeri 2007; Mattozzi and Merlo 2007; Reinikka and Svensson 2011). Previous research focusing on disclosures about firms has focused on how transparency affects market capitalization (Konar and Cohen, 1997; Bui and Mayer, 2003). We provide evidence of a key alternate pathway that allows information disclosure to affect regulatory outcomes: by allowing the public to hold governments accountable for implementing policies effectively.

environmental regulators, and polluters and how we used them to develop hypotheses about which types and forms of citizen appeals might be effective in reducing environmental emissions.

A. Public Participation in China's Environmental Governance

In the late 1990s and early 2000s, after two decades of rapid economic growth and industrialization, China faced severe air and water pollution problems, which caused increasing social unrest and protests across the country (Jing, 2000; Steinhardt and Wu, 2016). When President Hu Jintao took office in 2002, the central government launched a series of environmental policies and reforms, which mostly aimed at incentivizing local governments to tackle pollution, such as by setting explicit environmental performance targets for local officials (He et al., 2020), constructing automatic local pollution monitoring stations (Greenstone et al., 2022), and allowing local governments to charge pollution levies on large emitters (Gowrisankaran et al., 2020).

In addition to these "top-down" command-and-control type approaches to environmental protection, the central government also explicitly encouraged "bottom-up" initiatives in the form of citizen participation. Specifically, in 2006, the Ministry of Environmental Protection (MEP) issued the "Interim Measures for Public Participation in Environmental Impact Assessment," which emphasized the legal rights of citizens to get involved in making and implementing environmental policies.

Also in 2006, the MEP established the "12369 Environmental Appeals Center," which hosted an official national hotline (under the phone number 12369) that allowed citizens across the country to file environmental appeals about potential violations of pollution standards. Later, the MEP expanded the 12369 platform to include an official website. The MEP also instructed each prefectural city's environmental protection agency (EPA) to open an office to address appeals.[6] Nowadays, when a citizen makes an appeal via the 12369 platform, either by calling the hotline or leaving a message on the website, her appeal will be directed to the corresponding local EPA, which has legal responsibilities to investigate and issue fines to the polluter if a violation is confirmed. Between 2017 and 2019, the 12369 platform received a total of 1,860,149 appeals, 56% of which arrived by the hotline and the rest by the online platform.

In 2014, as part of China's grand "war on pollution," the central government released several additional policy documents that explicitly encouraged citizen participation in environmental

[6] The online appeal platform can be accessed via: http://1.202.247.200/netreport/netreport/index

protection, including the "Guiding Opinions on Promoting Public Participation in Environmental Protection" and the "Measures for Public Participation in Environmental Protection." In addition to reiterating the importance of the existing official channels for citizen participation in environmental protection, these policy documents laid out new channels that the public could use to participate in the enforcement of environmental policies. Specifically, the MEP required the prefectural EPAs to set up official accounts on popular Chinese social media platforms, namely Weibo and WeChat, to make it easier for the public and local EPAs to communicate. As of December 2017, all local EPAs in China's 338 prefectural cities operated official Weibo and WeChat accounts. In the past few years, an increasing number of citizens and NGOs have used the Weibo and WeChat platforms to express their dissatisfaction with violations of pollution standards (Wu et al., 2021). Specifically, we identified 5,336 Weibo posts between 2014 and 2016 reporting alleged violations by CEMS firms, 1,563 of which were posted by NGOs, and the rest by individual citizens. In 2018, a Jiangsu-based NGO named Public Environmental Concerned Center (PECC) filed 1,579 public appeals on Weibo based on pollution violations identified from the CEMS data.

Each prefectural EPA typically has a specific clerical staff member assigned to handle citizen appeals, including those filed via the 12369 platform, and the Weibo and WeChat accounts. Upon receiving an appeal, the staff member routes it to the EPA's relevant office (e.g., air, water, etc.), and then local enforcement teams decide what to do about the appeal. Sometimes, they may just call the polluting firm and collect relevant information. If they consider the case to be more severe, however, a team of inspectors will investigate the matter in the field. Once a conclusion is reached, the EPA will file a case report and decide whether the report can be shared with the person making the appeal. The EPA has significant discretion in levying penalties against violations.

B. China's Continuous Emissions Monitoring System (CEMS)

In 2004, to improve the quality of environmental management, the MEP launched a nationwide, automatic system of environmental monitoring that targeted key polluting firms. The system consisted of the installation of automatic monitoring equipment and the creation of a monitoring center to process the data. Automatic monitoring equipment includes apparatuses and flow (current) meters installed at the site of pollution sources to monitor pollutant discharges, CCTVs covering all pollution prevention and control facilities, data collection and transmission apparatuses, and other related facilities. Each local EPA houses a monitoring center that automatically collects data for each key pollutant from each installed meter in real time.

The CEMS monitors the emission concentrations of both water pollutants (COD and NH_3-N) and air pollutants (SO_2, PM, NO_X) for all the key polluters in China. Whether a firm is considered as a key polluter depends on its pollutant emissions in the previous two years. For example, to determine which water-polluting firms should be included in the CEMS list in 2019, the MEP examines all the water-polluting plants documented in the Chinese Environmental Statistics (CES) in 2017 and 2018 and ranks them by their COD and NH_3-N emissions in these two years. Those plants who rank above a certain cutoff are included in the 2019 CEMS list. Over time, the MEP has lowered the cutoffs and expanded the CEMS coverage. As of January 2020, the CEMS program monitored more than 24,620 plants that collectively accounted for more than 75% of China's industrial air and water pollutant emissions.[7]

While the CEMS monitoring started in 2004, the data was only shared internally with the government and the monitored firms prior to 2013. To increase transparency and facilitate citizen participation in environmental governance, the MEP released the "Measures for the Self-Monitoring and Information Disclosure of National Key Monitoring Enterprises (Trial)" in 2013, which required each provincial and prefectural EPA to establish its own CEMS and publicize in real time the hourly emissions data of every monitored plant to the public. The publicized CEMS data also includes standards for emission concentrations, which allows the public to check whether each plant violates its permitted standards each hour for each relevant pollutant.

The MEP exerts substantial effort to ensure the quality and authenticity of the CEMS data. First, the list of CEMS firms is publicized on the MEP website so that local governments cannot omit any CEMS firm from the publicized emission data. Second, the MEP has strict protocols for the installation and operation of the CEMS equipment: installation must be conducted by a third-party team designated by the MEP and 24-hour CCTVs are installed near the monitoring equipment as a deterrent to the plant from interfering with the equipment. Third, the MEP uses various algorithms and technologies to detect abnormalities and inconsistencies in the CEMS data and hosts monthly supervisory sessions to discuss any anomalies that are detected with the local EPAs. Fourth, the MEP

[7] While China currently operates the world's largest CEMS system, other countries use similar systems for various regulatory purposes. For example, the United States EPA and many state governments require firms to install CEMS equipment to demonstrate compliance with permitted emission levels (United States EPA 2021). In India, specific provinces have started to require firms to install continuous monitoring equipment to support emissions trading (Greenstone et al., 2020). Likewise, the European Union has made continuous emissions monitoring support operation of its Emissions Trading Scheme (EU 2021). Yet, none of these schemes have approached the scale of the CEMS in China, where it is used as a systematic regulatory tool for all key industrial polluters.

requires on-site inspections at least once a month to ensure the proper functioning of the automatic monitoring equipment and the proper compliance of the firms. Because of these efforts, the polluting plants and local EPAs have very limited scope to interfere with the CEMS, which we believe means that the publicized emission data is reliable with high probability.

Despite the central government's efforts to collect and publicize high-quality data, environmental law delegates the enforcement of pollution standards to local regulators. Specifically, if the CEMS data indicates that a firm violates an emissions standard, the environmental law requires that the local EPA conduct an onsite investigation to confirm the violation before punishing the firm. In addition, the issuance of substantial penalties (e.g., large fines or temporary shutdowns) involves two steps: the local EPA must issue a warning in response to a violation during an onsite visit to the firm and then detect a second violation during a subsequent onsite visit in the following month. It is not surprising that disclosing the CEMS data does not lead to perfect compliance on its own, given the information asymmetries between the central government and the local regulators and large polluters' potential to defy or capture local regulators. Additionally, both the central and local governments have competing goals of maximizing production and controlling pollution; these multiple goals mean that maintaining some flexibility in applying emissions standards is likely to be desirable, especially when violations do not cause significant public discontent.

To provide some quantitative context, Figure 1 plots the percentage of CEMS firms' monitored stacks violating emission standards daily between 2018 and 2021.[8] In January 2018, around 1.5% of monitored stacks violated air emission standards on any given day, and 0.6% violated water emission standards. In the following three years, the rate of daily violations for both water and air pollutants declined steadily. This pattern is consistent with China's overall improvement in ambient air quality and water quality since 2014. Even with this improvement, around 0.9% of the monitored firms violated air pollution standards and 0.3% violated water pollution standards on any given day in the year before our experiment (2019). Bringing all CEMS firms into compliance with standards would significantly improve China's environmental quality: if violating firms reduced pollutant concentrations to just below the standards in 2019 (assuming no change in emission flows), SO_2 emissions would drop by 279,000 tons, a 7% reduction in aggregate industrial SO_2 emissions and COD emission would drop by 31,000 tons, a 4% reduction in aggregate industrial COD effluents.

[8] Some CEMS firms can have multiple stacks being monitored, and can be monitored for multiple pollutants.

C. Background on Interactions between Citizens, Regulators, and Polluters

To help design the treatment arms, we researched the relationship between China's citizens, environmental regulators, and polluters with special attention to the role of citizen appeals. These efforts included conversations with environmental regulators, NGOs, polluting firms, and other relevant parties. Our visits with the directors and the staffs assigned to respond to citizen appeals of two prefectural environmental bureaus in Hebei and Jiangsu provinces were especially insightful.

The regulators reported that a key objective of their work is to minimize the risk of social unrest caused by concerns about high levels of pollution or the flouting of environmental regulations or standards. It is well known among the regulators that such social unrest has led to the removal of several directors of local environmental bureaus. Thus, a topline goal of preventing social unrest along with career concerns of government officials appears to create the conditions for a regulator that is responsive to the potential for citizen concerns about environmental quality to gather momentum. At the same time, the regulators indicated that they are aware of the need for robust local economic growth and this is a countervailing motivation.

In practice, the regulators described an approach designed to reduce the odds of public unrest. A key part of this strategy is to monitor public sentiments and opinions online, especially on social media, and to try to resolve any issues before they trigger wider public discontent. A specific part of the strategy is to convey responsiveness to citizen appeals, which, in practice, means that each local environmental bureau has a designated officer whose job is to respond to such appeals. According to the local environmental bureau's internal rules, all citizen appeals should be addressed, unless the information provided in the appeals is inaccurate or cannot be connected to a specific pollution source (e.g., there are frequent complaints of foul smells that are not connected to individual sources).

The regulators reported that the presumptive response to an appeal about a specific polluter is to send a team to the facility for an inspection. In practice, there are two types of inspections: general-purpose inspections and task-specific ones. The former is routine work for local environmental bureaus, during which the inspectors will check if the paperwork of the polluting firm (e.g., licenses, waste discharge permits, environmental assessment reports, etc.) is accurate and up to date. In some instances, the inspectors also check the abatement facilities during their visits, but this is not a requirement. However, task-specific inspections are different. For example, when inspectors visit a polluting firm because the firm is suspected to violate the emission standards, they bring equipment to test the pollutant concentrations onsite. If emission violations are verified by such onsite testing, the inspection teams can impose penalties and require the firms to make necessary corrections to its operations.

We were also invited to accompany the environmental inspection teams on a handful of inspections. An interesting observation from these visits was that almost all large polluting firms already have the capital equipment necessary to comply with the emission standards. One example is the wastewater treatment facilities that can almost entirely eliminate water emissions but only if it is operated at full capacity. However, firms incline to turn off certain equipment or skip abatement procedures from time to time due to high marginal costs associated with the operation of such energy-intensive equipment. When this happens, the emission concentrations will elevate and can even exceed the standards, which will be recorded by the CEMS as violations. Therefore, a pollution appeal can incentivize local regulators to incentivize firms to operate their abatement facilities properly.

Overall, these discussions were instrumental in devising the experiment's treatments because they helped us develop three broad hypotheses about the direct effects of citizen appeals on environmental compliance and emissions. First, all forms of citizen appeals could have the potential to reduce environmental emissions, because they all can lead to more frequent environmental inspections and raise firms' expected costs of violating environmental standards. Second, public appeals could be more effective than private ones, because they have higher potential to lead to civil unrest. Third, social media could be an especially effective means to express a public appeal because it is an inexpensive way for citizens to communicate and the regulator consequently monitors them. The next section describes the specific treatments that we devised to test these broad hypotheses.

III. Experiment and Data

This section describes the field experiment and data. Section III.A discusses the experimental design, Section III.B provides details on the experiment's implementation, Section III.C discusses ethical consideration, and Section III.D introduces the data and presents balance tests across the experimental arms.

A. Experimental Design

The sample is comprised of the 24,620 polluting firms required to install CEMS by the central government by January 1st, 2020. We randomly assigned these firms to several experimental arms designed to uncover the effects of private and public appeals, to shed light on the mechanisms that explain any resulting treatment effects, and to learn whether there are general equilibrium impacts. The main outcomes of interest include each firm's daily violation status and daily average air and water pollution emissions concentrations, as well as ambient SO_2 concentrations.

Experimental Arms: Public and Private Appeals. Figure 2 graphically depicts how these firms were randomly assigned to three broad groups of experimental arms: the control group (C), the "private appeals" group (T1), and the "public appeals" group (T2). Firms in these three groups differed in the kind of appeal they faced when they violated a pollution standard. Importantly, the treatments mirror existing and approved ways that citizens participate in environmental governance, though the impacts of these existing methods cannot readily be determined in observational data. Specifically, the three experimental arms and the proportion of firms assigned to them are:

- **Control Group (C):** When the CEMS data indicated that the firm violated its emission standards, we *did not* intervene in any way. About 1/7 of the CEMS firms were assigned to this group.
- **Private Appeals Group (T1):** When the CEMS data indicated that the firm violated its emission standards, a citizen volunteer filed a private appeal against that violation that was not observable by the public. About 5/7 of the CEMS firms were assigned to this group.
- **Public Appeals Group (T2):** When the CEMS data indicated that the firm violated its emission standards, a citizen volunteer wrote a post on Weibo (a popular Chinese social media platform comparable to Twitter), and "@" the official Weibo account of the corresponding local EPA. The post appealed to the EPA about the violation and demanded that the EPA investigate the issue. The appeal was phrased so that its content and wording were as close to identical as possible to

the T1 appeals, with the lone substantive difference being that it was done publicly. We assigned 1/7 of the CEMS firms to this group.

For each arm, we prepared a detailed script for the citizen volunteers to follow. The core content of these scripts remained consistent across T1 and T2, while we randomly varied the exact wording in each appeal to avoid appearing repetitive to the regulator or firm. Samples of these appeal scripts are translated and listed in Appendix B.

These three groups are used to infer the consequences of private and public appeals on several measures of environmental performance and are the paper's primary focus. The difference between T1 and C identifies the causal effect of *privately* appealing violations through various channels (as we explain next), relative to the impact of the status quo regulatory response to violations. Similarly, the difference between T2 and C identifies the causal effect of *publicly* appealing violations on social media, relative to the status quo. Furthermore, the difference between the T1 and T2 treatments naturally identifies the effect of public appeals relative to private ones.

Mechanisms. Within the groups of experimental treatments, we further randomized firms into specific treatment arms to investigate several potential mechanisms for the overall private (T1) and public (T2) treatment effects. Specifically, the T1 private appeals were delivered in several different ways following the MEE's recommended channels for citizen participation in environmental monitoring:[9]

- **Private Appeals to Regulator via Direct Message on Social Media Group (T1A):** A citizen volunteer sent a *private* message to the corresponding local EPA's official Weibo account, notifying them about the pollution violation and requesting that they investigate the issue.
- **Private Appeals to Regulator on Government Website Group (T1B):** A citizen volunteer filed a *private* appeal via the 12369 website to the corresponding local EPA, notifying the local EPA about the violation and requesting that they investigate the issue.
- **Private Appeals to Regulator through Government Hotline Group (T1C):** A citizen volunteer called the 12369 hotline to *privately* appeal to the corresponding local EPA. In the

[9] Naturally, our interventions cannot exhaust all the possible channels through which private pollution appeals can be filed. Nevertheless, we believe that the subset of appeal channels that we choose are the most common types of private pollution appeals in China. They were also explicitly endorsed by the MEE itself in its guidelines for citizen participation in environmental governance.

phone call, she notified the local EPA about the violation and requested that they investigate the issue.

- **Private Appeals to Firm through Phone Call (T1D):** A citizen volunteer called the violating firm to *privately* appeal the violation. In the phone call, she notified the firm about its violation and requested that they check the issue.[10]

Furthermore, we cross-randomized T1C and T1D, such that half of the firms receiving T1C also simultaneously received T1D, and vice versa. These sub-arms in T1 are randomized at the firm level. T1A and T1B each account for 1/7 of the CEMS firms, while T1C and T1D jointly account for 3/7 of the CEMS firms.

A comparison of the T1A – T1C treatment effects with the T1D treatment effect reveals whether private appeals to the government are more effective than private appeals to firms. Further, a comparison of the T1A – T1C treatment effects provides an opportunity to assess whether the government is more responsive to appeals through a particular medium. For example, an appeal delivered through a social media direct message (T1A) might indicate a greater risk that the violation will draw widespread attention than an appeal delivered via an older technology like a phone call (T1D). The interaction term between T1C and T1D created by our cross-randomization provides a test of whether there are complementarities in privately appealing to the regulator and to firms. Additionally, this interaction is indirectly informative about the nature of the T2 treatment effect, because public appeals by their very nature involve informing both the regulator and the firm.

Within the T2 treatment group, we did a second round of randomization at the *appeal* level to examine the role of publicity on regulatory efforts, given the regulator's objective to avoid civil unrest. We randomly assigned half of the T2 firms' violations to receive additional public attention by hiring a social media firm to increase the number of "likes" and "shares" for these Weibo posts. This group of violations is referred to as T2B, with the other half of violations receiving the treatment described above, which we refer to as T2A. Ultimately, the average number of "likes" and "shares" were 10.56 for T2B, compared to 0.66 for T2A. Among the T2B and T2A violations, we compare whether the Weibo appeal receives a response from the regulator, the response's length measured in words, and whether the response includes proof of an onsite inspection or audit of the violator. These outcome

[10] The phone number we used to contact the firms were the official numbers listed on the updated business registration records, which are the same numbers that governments and other businesses would use to contact these firms.

variables are collected through our Weibo exchanges with the local regulators and are currently not available for the other arms.[11]

General Equilibrium. We also experimentally investigate the indirect or general equilibrium consequences of the pollution appeals. Although the public and private appeals are applied at the firm level, they could also affect the ways that regulators enforced standards generally within their jurisdiction. On the one hand, regulatory resources may be fixed and their application to violators in the treatment group may crowd out the regulatory resources that would otherwise have been allocated to control firms or treatment firms that previously did not violate standards, potentially leading to an increase in emissions and violations by them. On the other hand, the treatment might cause a positive spillover effect by: (1) leading local governments to generically enforce environmental regulations because they interpret the increased appeals as an indication of the public's broad dissatisfaction with environmental quality, which may threaten their career developments; and (2) causing these firms to proactively reduce their emissions because they interpret the increased appeals and enforcement of violators as evidence of an increase in regulatory stringency. These broad forces work in opposite directions and whether one dominates is ultimately an empirical question.

To explore these possibilities, we cross-randomize treatment intensity across different regions. Specifically, 95% of the CEMS firms were assigned to the treatment groups in 60% of the prefectural cities ("95% prefectures") and 70% of the CEMS firms were assigned to the treatment groups in the other 40% of the prefectural cities ("70%" prefectures"). Different firm-level treatment arms are proportionally randomized within each prefecture. This "double randomization" design allows us to causally identify the general equilibrium effects of pollution appeals by comparing the violation rates and emissions of firms across the 95% and 70% prefectures, conditional on their treatment status. We also test whether ambient air pollution concentrations were equal in the 95% and 70% prefectures. A failure to reject the null hypothesis would be consistent with there being a fixed amount of regulatory resources and the treatments simply shifting effort from one set of firms to another.

[11] It is worth noting that, even if we can collect these violation-level outcome variables for all violations, we still will not be able to draw any causal conclusion from a comparison across C, T1, and T2. This is because the three main arms were randomized at the *firm* level, and during the experiment, any violation after the first one will be endogenous to the treatment received by that firm. As a result, the types of firms that keep committing violations, as well as the frequencies and severities of these subsequent violations could differ across C, T1, and T2, and thereby mechanically lead to differences in regulatory responses and efforts. We can compare these outcome variables across T2A and T2B, because these two sub-treatments were randomized at the *appeal* level.

B. **Experimental Implementation**

The experimental period started on May 6, 2020 and ended on December 31, 2020. The experiment included three key steps that were conducted on a daily basis. Specifically, we completed the following steps on a daily basis during the experiment: (1) identified and verified CEMS firms that violated the emission standards based on their emissions in the previous 24 hours; (2) filed different types of appeals as defined by the treatment assignments; and (3) documented any government responses to the appeals. Here we provide some more detail on each of these steps.[12]

For the first step, we combined an algorithm that we developed with human judgement to mimic the practical definition of pollution violations set by the Ministry of Ecology and Environment (MEE).[13] In real-time, the algorithm identified all firms violating the national emission standards, based on their average pollution emission concentrations in the previous 24 hours.[14] If a CEMS plant is being monitored for multiple pollutants, we identify it as a violator if it exceeds the emission standard for at least one pollutant. We then employed 12 environmental science graduate students to manually double-check each violation which the algorithm identified. Because the CEMS equipment often continues to run after production is suspended and there is little air flow in the post-production period, emissions concentrations can be abnormally high for a period of time. To remove these false positives, the graduate students identified the violations that occurred after production had stopped or that were due to mechanical spikes by examining complementary indicators such as oxygen demand and water/gas flows.

Once the students identified true violations of the emissions standards, they took screenshots from the CEMS webpages as proof (see Appendix B for details). This process was time-consuming; each of the 12 students spent 4 to 5 hours a day to screen and verify the violations from different provincial CEMS websites. Finally, we note that the students were blinded to treatment assignment.

The second step was to take the verified pollution violations and file appeals. Every day, we generated the list of verified violations, produced the exact script used for the appeal, and determined

[12] A few implementation details prior to the study period are worth mentioning. In January 2020, we collected the phone number of all the firms in the sample and the official Weibo account of every local EPA. Between January and March 2020, we trained research assistants to identify and verify violations of emissions standards, and trained citizen volunteers to file appeals via different channels following the experimental assignments. Additionally, we conducted a small-scale pilot in April to ensure all the research assistants could complete the daily tasks on time.

[13] The MEE was established in 2018 in replacement of the MEP.

[14] For each pollutant being monitored, the MEE determines a specific emission standard for each CEMS plant. Appendix Figure A1 plots the distribution of SO2 and COD emissions standards across all CEMS plants in our sample.

the delivery method based on the polluter's treatment assignment. The appeals were eventually filed by a field team consisting of citizen volunteers, whom we recruited through three environmental NGOs, using the content and experimentally determined delivery instructions that we provided them. Each volunteer was given no more than 15 appeals per day to provide enough time to follow the protocols (e.g., reporting by phone is limited to the working hours of the recipient). To avoid repetitive appeals, if a CEMS firm commits consecutive violations spanning multiple days, we waited until the next week before filing a second appeal. Appendix B describes the implementation protocol in greater detail and provides screenshots to visualize the appeals made by the citizen volunteers in each arm.

An additional part of the second step was amplification through social media. For the T2B arm, we hired an external social media promotion company to boost the publicity of appeals about violations. Specifically, the company added roughly 10 "likes" and "shares" to the Weibo appeals about the T2B violations, using a variety of existing and active company-operated Weibo accounts.

In the third step, the citizen volunteers tracked the responses to the appeals from the local governments, which primarily came back as Weibo direct messages, Weibo public replies, 12369 phone calls, and 12369 website replies. We recorded the timing and content of each government response and matched them to the corresponding pollution appeal.

Table 1 summarizes some basic facts about the experiment. First, the experiment covers the universe of 24,620 CEMS firms in China's 333 prefectures. During the 8-month treatment period, other citizens not affiliated with the research team filed a total of 271,859 pollution appeals to the government; 5,478 were explicitly about pollution violations committed by the CEMS firms.[15] In other words, the majority of these appeals do not target specific CEMS firms. Instead, most of the appeals are just about some unpleasant odors or dirty waters that people encounter near their communities. Usually, people would take some photos and file an appeal, without explicitly linking their complaint to specific firms or polluters. Second, the experiment was conducted in collaboration with the three NGOs, which collectively organized 15 citizen volunteers on an average day to file pollution appeals. During the study period, a total of 120 Weibo accounts were used by citizens to file pollution appeals. We also hired 12 Environmental Science graduate students to verify true pollution violations. Third, the CEMS raw data revealed 12,596 pollution violations during the study period, but our verification

[15] These numbers are based on the administrative data covering the universe of citizen appeals filed in 2020, which we obtained from the MEE. We excluded pollution appeals filed by the research team when calculating these numbers.

process concluded that there were 5,366 real violations. which were committed by 2,363 different CEMS firms.[16] We filed 2,941 appeals with the type dictated by the firms' treatment assignments; for the rest 2,425 violations, appeals were not filed because we did not appeal against violations committed by the control firms, nor did we file multiple appeals within a week about the same firm's violations. Our appeals generated 1,161 formal responses from government officials.

C. Ethical Considerations

Prior to implementing this experiment, we carefully considered the ethical implications of working with a partner non-governmental organization to file appeals. While Appendix C discusses the ethical considerations in more detail, several points are worth highlighting. First, the rights of citizens to make appeals against violations is legally protected and explicitly encouraged in national policy. All local governments are mandated to operate the multiple channels of making appeals that we study in this experiment. Second, we consulted with several non-governmental organizations that already had multiple years of experience making appeals and were not advised of any repercussions to their staff or organizations. Third, we worked with a non-governmental partner that was already active in environmental monitoring, so the treatments are not outside of the existing scope of their work. Fourth, we were in daily contact with our partner organization and never learned of any adverse events or pressures in response to the appeals. Finally, because we did not collect data from or about any individual people, two separate IRBs in the United States determined that this study was not considered human subjects research.

D. Data, Balance Tests, and Empirical Description of the Treatments

The analysis is conducted on a data set that results from combining several sources of information. These MEE data cover all the CEMS firms and include information on firm name, social credit code, industry, main pollutant type, hourly emission concentrations of various pollutants, hourly gas and water flows, pollution violation status, among other measures. In 2020, due to the COVID-19 lockdown, most CEMS firms suspended production until the economy reopened in mid-March, so we drop the first 10 weeks of the 2020 CEMS data from the sample.[17] The official database of CEMS

[16] Here if a firm simultaneously violated the emissions standards in multiple stacks or for multiple pollutants, we count that as one daily violation. Consecutive violations spanning multiple days are also combined as one violation. As a result, the violation rate in Table 1 is substantially smaller than the violation rate indicated by Figure 1.

[17] Note that from mid-January to mid-March 2020, China was struck by COVID-19 and many CEMS firms suspended their production due to compulsory lockdowns. By late March 2020, however, almost all Chinese cities re-opened because

firms was matched to our experimental data, including treatment arm, specific appeals, and government responses.[18]

Two other government data sets were critical ingredients. First, we merged in MEE data on all citizen appeals against the CEMS firms in 2020 made either through the 12369 website or by phone. This database of appeals includes ones filed by other citizens on their own volition and the ones generated by the experiment. Second, we also merged in the Ministry of Commerce's administrative data on firm registrations that contains information on date of establishment, industry, business address, business type, registration status, and other measures. We merged these data with the CEMS data using the social credit code.

Table 2 reports on balance tests across the experimental arms. In Column (1), we present the mean and standard deviation of the control group, for variables such as the share of firms in different industries, the total amount of pollution penalties paid in the previous year, frequent violators in the previous year, and various measures of pre-treatment environmental performance (in the eight weeks before the treatment began), including severity of violations and emission concentrations. We then compare each treatment arm to the control arm, implemented by running a regression of each outcome variable on a set of treatment dummies. In Columns (2) to (6), we present the regression coefficients and standard errors for each variable-arm combination. As we can see, the treatment arms are well balanced with the control arm along almost all dimensions, confirming that our randomization was well executed. Appendix Table A1 also reports the detailed breakdown of industries by experimental arm.

IV. Empirical Results

This section presents the baseline analysis from the estimation of the following econometric model:

$$Y_{ijt} = \sum_j \alpha_j T_{ij} \cdot Post_t + \gamma_i + \eta_t + \epsilon_{ijt} \quad (1)$$

where Y_{ijt} is the outcome of interest for firm i, assigned to arm j, on day t. T_{ij} represents the randomly assigned arm of firm i and it is interacted with $Post_t$, which is a dummy variable that equals

COVID-19 was already deemed under control. During the experimental period, production fully resumed and firms operated as usual.

[18] For analysis, we use the official CEMS data provided annually by MEE, rather than the data published daily on the provincial government websites used to identify violations. The official data from MEE are more complete and have been cleaned of basic errors that occasionally appear in the real-time data.

one after the experiment commenced.[19] The outcome is also adjusted for firm fixed effects, γ_i, and day fixed effects, η_t. Since we cross-randomize treatment intensity at the prefecture level, we also estimate more saturated specifications that include province-by-day fixed effects to control for time-varying differences in regional enforcement. Standard errors are clustered two-way by prefecture and week.

The α_j's are the parameters of interest. They measure the causal effect of each of the treatments relative to the controls during the experiment. In this section, we report on specifications that estimate the average effects of T1A – T1D private appeal treatment arms and the T2A and T2B public appeals treatments. We examine specific treatment arms when analyzing the underlying mechanisms.

Section IV.A presents the main findings on pollution violations and emissions. In Section IV.B, we discuss the heterogeneous treatment effects.

A. Pollution Appeals and Environmental Performance

Table 3 summarizes the results from the estimation of two versions of equation (1) for three measures of environmental performance. For each outcome, the column "a" specification includes firm and day (e.g., December 6, 2020) fixed effects and the column "b" specification replaces the day fixed effects with province by day fixed effects. In columns (1a) and (1b), the outcome is $violation_{ijt}$, which is a dummy variable indicating whether firm i committed any pollution violation on day t. In the next two pairs of columns, the outcome variables are the firms' daily emission concentrations of SO_2 for air pollution, and COD for water pollution. These two pollutants have the highest coverage for CEMS firms and are the most high-stakes "criterion pollutants" for evaluating the environmental performance of local government officials (He et al., 2020).

Violations. The results indicate that appeals greatly reduce violations, especially public appeals. In the richer column (1b) specification, the private appeals treatment (T1) reduces the probability of a daily violation by 0.227%, relative to the control group; this is about 24% of the control group's mean of 0.936%. The public appeals treatment (T2) decreases the probability of a violation by more; it reduces it by roughly 62% of the control group's mean. The table also documents that the difference in magnitudes is statistically significant as the null hypothesis that the public appeals treatment is

[19] The week of May 7th is the 18th week of the year. Since the first 10 weeks are excluded from our sample due to COVID lockdown, the pre-treatment period corresponds to the first 7 weeks in our sample.

smaller in magnitude than the private one is rejected at conventional significance levels. Finally, we note that the results are quantitatively similar across the two specifications.[20]

Figure 3 provides an opportunity to understand how the treatment effects evolve over time. Specifically, it reports the results from fitting a version of the column (1a) specification where the treatment and $Post_t$ interactions are replaced with treatment and week interactions. For both the private and public treatments, nonzero treatment effects emerge within a couple of weeks of the experiment's initiation. It is sensible that they do not appear immediately, because the appeals are not initiated until a firm commits a violation. By week 20, it appears that both the T1 and T2 treatment effects have stopped increasing and stabilized at a level larger in magnitude than reported in Table 3 (which is an average over the entire experiment); this pattern suggests that the Table's estimates understate appeals' long-run potential to reduce the incidence of violations. We also disaggregate T1 and present the trends of each sub-treatment arm, which show similar patterns. Moreover, it is reassuring that there is no evidence of a treatment effect in the period before the RCT began for either the private or public appeal arms, confirming that the randomization was well executed. Overall, these figures suggest that the long-run partial equilibrium effect of the treatments are larger than is reported in Table 3.

Emissions. Returning to Table 3, the entries in columns (2) and (3) indicate that the public appeals treatment (T2) caused substantial reductions in air and water pollution emissions concentrations, while the private treatments (T1) led to much more modest reductions. The results from the preferred (2b) and (3b) specifications reveal that public appeals reduced the average firm's daily average SO_2 emission concentration by 16.2 ug/m^3 and its daily average COD emission concentration decreased by 2.2 ug/L; these are 12.2% and 3.7% declines from the control group's SO_2 and COD emission concentration levels, respectively. Further, the estimates also indicate that the private appeals

[20] We conduct additional checks in the appendix. First, in Table 3, we defined pollution violations based on whether the monitored emission concentration exceeded the standard value set by the MEE. However, it is possible that some of these monitored values are driven by mechanical errors or production suspensions, instead of actual pollution violations. In Appendix Table A2, we refine the definition of pollution violations to exclude cases with minimal levels of measured air flows as these may be instances when the plant is not operating. The results with this alternative definition of a violation are qualitatively the same as those in Table 3, confirming the powerful effect of the public appeal treatment at reducing violations and the more modest effect of private appeals. Second, in Appendix Table A3, we report alternative standard errors by clustering at either the prefecture level, or at the prefecture-by-arm level, and if anything, the statistical significance increases under these specifications. Third, in Appendix Table A4, we aggregate the data to either the firm-month level or the firm-week level and run Poisson regressions with the same set of baseline fixed effects, and the main results still hold.

treatments reduced these two measures of air and water emissions concentrations, but the effects are much smaller and would not be judged to be statistically significant by conventional criteria.[21]

Figure 4 provides an opportunity to understand where in the distribution of emissions concentrations the Table 3 columns (2) and (3) estimates of public appeals come from. We report the results from fitting the preferred version of equation (1) with province by day fixed effects separately on indicators for whether a firm's daily SO2/COD emissions concentration was 0–40% of the corresponding emissions standard, 40–80%, 80–100%, 100–200%, and >200%. As we can see, under public appeals, firms' emissions concentrations became less likely to exceed the national standards, which is especially true for extreme violations where their emissions concentrations more than doubled the national standards. Interestingly, these shifts in emissions concentrations appear to be infra-marginal: the T2 firms did not fall in the "barely compliant" bin (80–100%) more frequently. Instead, they became much more likely to fall in the "highly compliant" bin, where their emissions concentrations were below 40% of the national standards. This is consistent with the qualitative observation that most pollution violations committed by CEMS firms were driven by discontinued operations of their abatement facilities (in order to reduce energy use), and once these facilities become properly functioning, most CEMS firms' emissions concentrations can fall well below the designated emissions standards.

Additionally, we investigated whether the reduction in average emissions concentrations translated into reductions in total emissions, which are the relevant metrics for determining the impact on individuals' exposure to ambient pollution.[22] The impacts on emission concentrations and total emissions could differ if the treatments cause the plants to change their intensity of operations (e.g., a decline in concentration could be offset by an increase in the number of hours of operation or running the plant at full capacity more frequently during operating hours). While the CEMS data does not directly report hourly data on total emissions, we infer the changes in total emissions by investigating the average hourly gas/water flows reported by the CEMS; the product of these variables and the emission concentrations equal average total emissions per hour for each pollutant. Appendix Table

[21] Appendix Figure A2 is constructed identically to Figure 3 and reports on how the emissions concentration treatment effects evolve over time. Here too, the treatment effect grows over time, especially for the private appeals, presumably as violations cause the polluters to learn about the experimentally induced increase in scrutiny. The takeaway is that the treatments' long-run equilibrium effects on emissions are larger than those reported in Table 3.

[22] It is common for regulators around the world to focus on emissions concentrations, even though it is total emissions that matter for human health. For example, regulators in India and the United States focus on enforcing emissions concentration standards.

A5 reveals that none of the treatments had a meaningful impact, either economically or statistically, on the flow of pollutants. We conclude that there were reductions in emissions concentrations and total emissions.

B. Heterogeneity in Treatment Effects, Based on Firm Characteristics

Table 4 tests for heterogeneity in the treatment effects based on whether firms are state-owned enterprises, produce "final" (rather than "intermediate") goods that might make them more concerned about their public image,[23] and whether they committed violations during the seven-week pre-treatment period. The state-owned enterprise tests are reported in columns (1a), (1b), and (1c) for the violation rate, SO2 emissions concentration, and COD emissions concentration, respectively. The analogous regression results for the other two categories are reported in (2a) – (2c) and (3a) – (3c). Throughout the table, we report the results from the more demanding regression that includes firm and province-by-day fixed effects.

A salient finding in Table 4 is that the overall treatment effects are driven by the firms that committed violation during the seven weeks prior to the experiment (columns 3a – c). Indeed, there is little evidence of any treatment effect among the subsample of firms that did not violate in the pre-treatment period.[24] Additionally, the treatment effects for the state-owned enterprises are larger in magnitude than for private firms, although the difference is not statistically significant by conventional criteria. Finally, there is little consistent evidence that the treatment effect is different for final goods firms, compared to the rest of the sample, indicating that "corporate social responsibility" concerns are unlikely to be the driving force behind the main results.

V. Mechanisms

The previous section's results confirmed the paper's three broad hypotheses that: i) citizen appeals improve environmental performance; ii) public appeals are more effective than private ones; and iii)

[23] This variable is defined based on industry code in the business registration data.
[24] The amount of frequent and non-frequent violators is balanced across different experimental arms. This heterogeneity could be mechanical, given that the frequent violators have a larger room for improvement. Another possibility is that, frequent violators might be more responsive to citizen appeals. Comparing how frequent and non-frequent violators' emissions changed after they received their first appeals in our experiment, we find no evidence of differential responsiveness, thus suggesting that the heterogeneity might be mechanically driven by the difference in baseline violation rates.

social media is an especially effective way to deliver public appeals. This section explores several more subtle channels that might explain the specific estimated treatment effects.

A. Private Appeals

Table 5 provides an opportunity to explore the mechanisms that underlie the overall T1 treatment effect by disaggregating the effects into treatment arms. There is little evidence that private appeals to the government are more effective than private appeals to firms across the three outcomes, as confirmed at the bottom of the table, which reports the p-value from a test of the null hypothesis that the effects of T1A, T1B, T1C, and T1D are equal. Similarly, there is little evidence that the channel through which the private appeals are delivered matters as the null that T1A, T1B, and T1C are equal cannot be rejected at conventional significance levels.

Table 5 also reveals that privately informing both the government and the firm has little effect on the outcomes (see the coefficient associated with the interaction of the T1C and T1D treatments). This finding indicates that there are not complementarities in privately appealing to the regulator and to firms, which also suggests that creating common knowledge between the government and the firm is not sufficient in generating treatment effects that are comparable to the public appeals.

B. Public Appeals

We now investigate why the public appeals caused such significant improvements in environmental performance. As we outlined above, a natural hypothesis is that failures to prevent collective actions or civil unrest could prevent the promotion case of a local official, so officials have overarching incentives to respond to public attention about a violation with greater regulatory effort. To test this hypothesis, we created variation in the visibility of public pollution appeals, by experimentally increasing the number of "likes" and "shares" for half of the T2 public appeals posted on Weibo. We then compare regulatory effort across three outcomes between these promoted appeals (T2B) and appeals that were not promoted (T2A).

Table 6 reports the results of fitting an equation where the outcome is a measure of regulator response to a public appeal on Weibo about a pollution violation. The explanatory variable of interest is an indicator for the T2B treatment that involves the appeal's promotion. This is a cross-sectional regression, and the unit of observation is a pollution appeal that we posted on Weibo regarding a T2 firm's violation. The dependent variables are an indicator for whether the Weibo appeal receives a response from the regulator (columns 1a and 1b), the response's length measured in words, where non-response is coded as zero (columns 2a and 2b), and an indicator for whether the response includes proof of an onsite inspection or audit of the violator (columns 3a and 3b). The "a" specifications include fixed effects for the day of the violation and the "b" specifications add province fixed effects.

The Table 6 results make clear that environmental regulators are responsive to publicity about violations. The columns 1a–b results indicate that the T2B treatment that boosts Weibo likes/shares increases the probability that the regulator replies to the Weibo appeal by approximately 6 percentage points, which is a roughly 40% increase in the baseline response rate of 15.5 percentage points. The treatment causes the average length of the response to more than double (columns 2a– b) and the probability of a documented onsite inspection or audit to increase by more than 60%. These results suggest that more publicity significantly increases local governments' responsiveness and effort to regulate pollution, as well as indicating the power of social media networks to provide a forum to launch the publicity.

We investigated several other potential mechanisms for the public appeal results but failed to find evidence for them. For example, it is possible that the public appeals posted on social media as part of the experiment inspired other citizens to file their own appeals against the pollution violations, thereby increasing the overall impact of public appeals. To investigate this potential channel, we obtained the universe of citizen appeals data from the 12369 website and the MEE and matched this information to each CEMS firm in our sample. We found that our interventions did not significantly change the number of appeals filed by other citizens (Appendix Table A6). These null results are precisely estimated, suggesting that the effect of publicly appealing violations is not driven by crowding in other appeals.[25]

Another possibility is that polluting firms might respond to public appeals by manipulating the CEMS monitoring data, rather than abating pollution. If this were the case, it would mean that the paper's finding that public appeals cause improvements in environmental performance may not be valid. As explained in Section IIB, the CEMS utilizes a series of technologies and follows strict protocols to ensure the accuracy of the data, which, in principle, leaves little room for firms to influence the automatic emission readings. Nevertheless, we investigated this possibility by comparing the frequency of suspicious readings across the experimental arms. The results in Appendix Table A7

[25] Relatedly, we also investigate whether the cross-randomized "likes" and "shares" led to more appeals from other citizens, given the higher visibility of these appeals. As shown in Appendix Table A8, we find no such evidence.

indicate that the experimental interventions had no impact on the probability that the CEMS were operated for fewer than 20 hours in a day or the probability that the CEMS recorded unusually low emission concentrations. These findings suggest that data manipulation is unlikely to drive our main findings.[26] Moreover, as we will discuss in detail in Section VI, the findings on firm-level emission reductions are corroborated by changes in ambient pollution levels at the prefectural city level, further supporting that the baseline findings that appeals, especially public ones, cause improvements in firms' environmental performance.

Further, it is possible that public appeals on social media cause local regulators to vigorously regulate violations to avoid sanctions or oversight from the central government (Anderson et al., 2019; Buntaine et al., 2021b). This mechanism is unlikely in our context, since any citizen appeal in the 12369 platform is automatically documented in the MEE's central system, meaning there is little scope for information asymmetries between the MEE and the local EPAs about appeals. Nevertheless, we tested this possibility directly. In a random half of the private Weibo appeals (T1a), we further threatened the local regulator that "if the issue does not get resolved, we will bring it to the upper-level government." The results in Appendix Table A9 indicate that this threat did not have a statistically meaningful effect on any of the three measures of regulatory effort, suggesting that concerns about central government involvement do not drive the baseline findings.[27]

Finally, another potential channel is that public pollution appeals are effective because they can get more citizens involved in complaining (i.e., through likes and shares) relative to private appeals. In other words, if many citizens engage in private appeals about the same violation, then such private appeals might become as effective as public appeals. We probe this possibility by exploring the natural variation in the administrative data on all 12369 appeals, and test whether having more citizens appealing about a pollution violation would cause the violator to reduce emissions more and become more compliant in the following months. As shown in Appendix Table A10, conditional on the severity of a violation, receiving multiple private appeals has no extra impact compared to receiving

[26] We define a firm's missing hours as "unusually high" if it records more than 4 hours of missing CEMS data in a given day; we define a firm's emission concentration reading as "unusually low" if it records an average emission concentration level below 10% of its yearly average on a fully operating day.

[27] Relatedly, we tested the possibility that the local officials were afraid of potential mainstream media exposure, by randomly threatening to contact local newspapers about the violation. As shown in Appendix Table A9, this also had no significant impact on regulatory effort, although some of these coefficients are imprecisely estimated.

just one private appeal. These observational findings indicate that the role of "publicity" is not limited to just involving more citizens in voicing their appeals.

VI. General Equilibrium Impacts of Pollution Appeals

Except for rare exceptions (e.g., Crépon et al., 2013; Egger et al., 2019), randomized control trials produce causal *partial equilibrium* estimates of an intervention but cannot provide evidence on the intervention's *general equilibrium* or indirect consequences. This setting is one where knowledge of the general equilibrium consequences may be especially important. This is because it is at least plausible that regulators responded to public and private appeals by shifting inspections and other regulatory effort between firms, allowing untreated firms to increase their emissions due to the reduced regulatory scrutiny. If appeals only shift enforcement, it is possible that they had little or even zero impact on total emissions and ambient pollution concentrations.

We designed the experiment to learn about the general equilibrium consequences of appeals by cross-randomizing treatment intensity across regions. Specifically, in 60% of the prefectural cities, 95% of the CEMS firms were assigned to the treatment groups, while in the other 40% of the prefectural cities, 70% of the CEMS firms were assigned to the treatment groups. We implement several tests, based on this cross-randomization, to assess the general equilibrium impacts.

Table 7 examines the impacts on ambient SO_2 pollution concentrations using data from national air quality monitoring stations in China, which are independent from the CEMS network and cannot be influenced by the CEMS firms. The entries come from the estimation of:

$$SO2_{st} = \alpha \cdot High_s \cdot Post_t + \gamma_s + \eta_t + \epsilon_{st} \tag{2}$$

where $SO2_{st}$ is the average ambient SO_2 concentration recorded in prefecture s on day t; $High_s$ is a dummy variable indicating whether prefecture s was experimentally assigned to the high-treatment-intensity group where 95% of the CEMS firms are assigned to one of the treatment arms; $Post_t$ is a dummy variable indicating whether day t is after the treatments were initiated; and γ_s and η_t are prefecture and day FEs, respectively. The coefficient of interest is α, which measures the effect of the 95% treatment, relative to the 70% treatment (there is not a control group of cities with zero appeals). Standard errors are clustered two-way by prefecture and week. Finally, we note that we only examined SO_2 concentrations, because industrial production is responsible for more than 80% of China's total

SO_2 emissions, while less than 50% of China's total COD emissions are from industrial sources, meaning that this outcome is unlikely to have sufficient statistical power.

The estimates displayed in Table 7 reveal relative reductions in ambient SO_2 concentrations in the high-intensity prefectures. Specifically, SO_2 concentrations decreased by more than 3.5% in the 95% prefectures, relative to the 70% ones. This finding, despite being noisy, is quite striking, because ambient air quality measures have limitations for detecting the effect of the public and private appeal interventions.[28] In addition to testifying to the far-reaching impacts of the nationwide interventions, the findings on ambient pollution also confirm that at a minimum the baseline improvements in firms' environmental performance cannot be entirely explained by their manipulation of the CEMS data. Finally, we note that these results would lead to the rejection of the null hypothesis that there are countervailing general equilibrium forces that perfectly undo the treatment's partial equilibrium improvements in environmental performance documented in the preceding tables. In Appendix Figure A3, we see that the treatment effect on ambient SO_2 concentrations appears to increase over time, which is consistent with a positive general equilibrium effect as firms learn about increased public scrutiny, although statistical imprecision prevents definitive conclusions.

Table 8 returns to the firm data and estimates the impact of assignment to the 95% prefecture group, relative to the 70% group, on violations, SO_2 emissions, and COD emissions, with the aim of better understanding the treatments' general equilibrium impacts. Specifically, we estimate a version of equation (2) with daily observations on these firm-level outcomes. These regressions provide an opportunity to separately test for a general equilibrium response among control and treatment firms by assessing whether either of the following two opposing forces dominates: 1) limited regulatory resources cause regulators to shift enforcement to the CEMS firms subject to appeals, and the firms not subject to the experimentally-induced appeals responding by *increasing* their emissions; and 2) some combination of a secular increase in enforcement or firms' response to a perceived increase in regulatory intensity causing these firms to *reduce* emissions.

In Panel A, the sample is limited to control firms that were not directly affected by the treatment, meaning that this group provides a straightforward test of the net effect of these potential general equilibrium forces. The point estimates in column (1) suggest that control group violations did not

[28] For instance, ambient air quality measures are affected by other local emission sources (e.g., household coal consumption and non-CEMS polluting firms) and emissions from other jurisdictions because SO_2 can travel hundreds of miles. Additionally, changes in meteorological conditions can significantly influence ambient air quality.

vary significantly across the 95% prefectures and the 70% ones. The SO_2 and COD emissions estimates point in opposite directions with neither being near statistical significance.

Panel B conducts the same exercise for the treatment firms. Here too, in the absence of general equilibrium impacts, there is no reason for these measures of environmental performance to vary between the two groups of prefectures. The probability of a violation is 20% lower in 95% prefectures, relative to the 70% prefectures for the treatment firms, in the more robust column (1b) specification; these estimates are statistically significant at the 10% level. There is also no evidence of a difference in average SO_2 or COD concentrations.

Overall, we conclude that the partial equilibrium treatment effects were not zero sum, because the reductions among targeted plants were not undone by increased emissions from other plants. Indeed, it appears that the general equilibrium impacts might even be positive for the treatment firms, perhaps indicating that direct regulation and general deterrence are complementary.

VII. Conclusion

There are three main findings from this paper's nationwide field experiment in China that randomly appealed privately and publicly against pollution violations through officially sanctioned channels. First, public appeals to the regulator through social media reduced violations by more than 60%, and decreased air and water pollution (SO_2 and COD) concentrations by 12.2% and 3.7%, respectively. In contrast, private appeals caused more modest environmental improvements. Interestingly, the emissions reductions were concentrated among the plants that grossly exceeded the standard prior to the experiment, rather than those just above the standard, and the violations reductions were concentrated among plants that frequently exceeded the standard prior to the experiment.

Second, experimentally increasing the visibility of social media appeals about a violation by adding "likes" and "shares" to the Weibo post increased regulatory effort. Specifically, this intervention caused an increase in the probability of a regulator replying to the appeal by 40%, a doubling of the length of written replies to appeals, and the probability of an onsite investigation to jump by nearly 65%. Overall, we conclude that increased regulatory effort is an important source of the treatments' positive effects on firms' environmental performance.

Third, we find that the general equilibrium effects do not offset the partial equilibrium effects. If anything, they may even strengthen the partial equilibrium effects. This rare opportunity to assess the general equilibrium consequences of an experiment is based on randomly varying the share of firms subject to the treatments across China's 333 prefectures.

A complete cost-benefit analysis of pollution appeals is beyond the scope of this paper, but we can make a few observations about some key components of such a calculation. The paper's estimates suggest that total pollution violations in China would be reduced by nearly 51,000, or more than 50%, if all polluting firms had their emissions scrutinized by the public and their violations appealed publicly. Further, this would reduce China's total industrial SO_2 emissions by 9.2% and total industrial COD emissions by 2.9% relative to the baseline. A complete accounting of the benefits would require reliable local air quality models to convert these emissions reductions into reductions in ambient air and water pollution and information on the willingness to pay for these improvements. On the cost side, we were unable to obtain data that would allow for the costs that firms incurred to reduce their emissions. However, it seems reasonable to presume that the marginal costs of citizens filing pollution appeals are relatively low, given the existence of the CEMS infrastructure.

The paper has at least a few broader implications. First, it provides experimental evidence on the impacts of citizen complaints and appeals in environmental governance and underscores the power of social media in facilitating citizen involvement in enforcing policies in China. The results imply that social media provides strong signals of public demand for stringent enforcement, which in turn prompts regulators to recalibrate their approach to the tradeoffs involved with environmental regulation. Second, it deepens our understanding of how governments, firms, and citizens interact in China's local governance system. It shows that regulators use participation to gauge the value of imposing costly regulations on firms, and particularly so when lax enforcement has the potential to generate publicity. In addition, it demonstrates that the failure to strictly enforce existing environmental policies is unlikely due to limited regulatory capacity, but instead largely driven by the lack of bottom-up pressure. A promising direction of future research is therefore trying to understand how to get more citizens to spontaneously participate in environmental governance. Finally, there is an extensive debate about the degree to which governments that are not held accountable by voting are accountable to their citizens. This paper's findings demonstrate that these governments still face important sources of accountability, and indeed China's "War on Pollution" illustrates this point more broadly (Greenstone et al., 2021).

References

Acemoglu, Daron, Tarek A. Hassan, and Ahmed Tahoun. "The power of the street: Evidence from Egypt's Arab Spring." *The Review of Financial Studies* 31, no. 1 (2018): 1-42.

Adhvaryu, Achyuta, Namrata Kala, and Anant Nyshadham. "Management and shocks to worker productivity: evidence from air pollution exposure in an Indian garment factory." *Unpublished working paper, University of Michigan* (2016).

Allcott, Hunt, Luca Braghieri, Sarah Eichmeyer, and Matthew Gentzkow. "The welfare effects of social media." *American Economic Review* 110, no. 3 (2020): 629-76.

Anderson, Sarah E., Mark T. Buntaine, Mengdi Liu, and Bing Zhang. "Non-Governmental Monitoring of Local Governments Increases Compliance with Central Mandates: A National-Scale Field Experiment in China." *American Journal of Political Science* 63, no. 3 (2019): 626-643.

Bai, Chong-En, Chang-Tai Hsieh, and Zheng Song. "Special deals with Chinese characteristics." *NBER Macroeconomics Annual* 34, no. 1 (2020): 341-379.

Banerjee, Abhijit V., Rukmini Banerji, Esther Duflo, Rachel Glennerster, and Stuti Khemani. "Pitfalls of participatory programs: Evidence from a randomized evaluation in education in India." *American Economic Journal: Economic Policy* 2, no. 1 (2010): 1-30.

Banerjee, Abhijit, and Esther Duflo. "Addressing absence." *Journal of Economic Perspectives* 20, no. 1 (2006): 117-132.

Bakshy, Eytan, Solomon Messing, and Lada A. Adamic. "Exposure to ideologically diverse news and opinion on Facebook." *Science* 348, no. 6239 (2015): 1130-1132.

Beraja, Martin, Andrew Kao, David Y. Yang, and Noam Yuchtman. *AI-tocracy*. No. w29466. National Bureau of Economic Research, 2021.

Björkman, Martina, and Jakob Svensson. "Power to the people: evidence from a randomized field experiment on community-based monitoring in Uganda." *The Quarterly Journal of Economics* 124, no. 2 (2009): 735-769.

Bui, Linda TM, and Christopher J. Mayer. "Regulation and capitalization of environmental amenities: evidence from the toxic release inventory in Massachusetts." *Review of Economics and Statistics* 85, no. 3 (2003): 693-708.

Buntaine, Mark T., Patrick Hunnicutt, and Polycarp Komakech. "The challenges of using citizen reporting to improve public services: A field experiment on solid waste services in Uganda." *Journal of Public Administration Research and Theory* 31, no. 1 (2021): 108-127.

Buntaine, Mark T., Bing Zhang, and Patrick Hunnicutt. "Citizen Monitoring of Waterways Decreases Pollution in China by Supporting Government Action and Oversight." *Proceeding of the National Academy of Sciences* 18, no 29 (2021): e2015175118.

Burgess, Robin, Matthew Hansen, Benjamin A. Olken, Peter Potapov, and Stefanie Sieber. "The political economy of deforestation in the tropics." *The Quarterly Journal of Economics* 127, no. 4 (2012): 1707-1754.

Bursztyn, Leonardo, Georgy Egorov, Ruben Enikolopov, and Maria Petrova. *Social media and xenophobia: evidence from Russia*. No. w26567. National Bureau of Economic Research, 2019.

Campante, Filipe R., Davin Chor, and Bingjing Li. *The Political Economy Consequences of China's Export Slowdown*. No. w25925. National Bureau of Economic Research, 2019.

Chang, Tom, Joshua Graff Zivin, Tal Gross, and Matthew Neidell. "Particulate pollution and the productivity of pear packers." *American Economic Journal: Economic Policy* 8, no. 3 (2016): 141-69.

Chen, Yuyu, and David Y. Yang. "The Impact of Media Censorship: 1984 or Brave New World?." *American Economic Review* 109, no. 6 (2019): 2294-2332.

Chen, Xi. *Social protest and contentious authoritarianism in China*. Cambridge University Press, 2012.

Chen, Jidong, Jennifer Pan, and Yiqing Xu. "Sources of authoritarian responsiveness: A field experiment in China." *American Journal of Political Science* 60, no. 2 (2016): 383-400.

Crépon, Bruno, Esther Duflo, Marc Gurgand, Roland Rathelot, and Philippe Zamora. "Do labor market policies have displacement effects? Evidence from a clustered randomized experiment." *The Quarterly Journal of Economics* 128, no. 2 (2013): 531-580.

Currie, Janet, Lucas Davis, Michael Greenstone, and Reed Walker. "Environmental health risks and housing values: evidence from 1,600 toxic plant openings and closings." *American Economic Review* 105, no. 2 (2015): 678-709.

Distelhorst, Greg, and Yue Hou. "Constituency service under nondemocratic rule: Evidence from China." *The Journal of Politics* 79, no. 3 (2017): 1024-1040.

Duflo, Esther, Michael Greenstone, Rohini Pande, and Nicholas Ryan. "Truth-telling by third-party auditors and the response of polluting firms: Experimental evidence from India." *The Quarterly Journal of Economics* 128, no. 4 (2013): 1499-1545.

Duflo, Esther, Michael Greenstone, Rohini Pande, and Nicholas Ryan. "The value of regulatory discretion: Estimates from environmental inspections in India." *Econometrica* 86, no. 6 (2018): 2123-2160.

Ebenstein, Avraham, Maoyong Fan, Michael Greenstone, Guojun He, and Maigeng Zhou. "New evidence on the impact of sustained exposure to air pollution on life expectancy from China's Huai River Policy." *Proceedings of the National Academy of Sciences* 114, no. 39 (2017): 10384-10389.

Ebenstein, Avraham, and Michael Greenstone "Childhood Exposure to Particulate Air Pollution, Human Capital Accumulation, and Income: Evidence from China" (2022)

Egger, Dennis, Johannes Haushofer, Edward Miguel, Paul Niehaus, and Michael W. Walker. *General equilibrium effects of cash transfers: experimental evidence from Kenya*. No. w26600. National Bureau of Economic Research, 2019.

Enikolopov, Ruben, Alexey Makarin, and Maria Petrova. "Social media and protest participation: Evidence from Russia." *Econometrica* 88, no. 4 (2020): 1479-1514.

Gavazza, Alessandro, and Alessandro Lizzeri. "The perils of transparency in bureaucracies." *American Economic Review* 97, no. 2 (2007): 300-305.

Gowrisankaran, Gautam, Michael Greenstone, Ali Hortaçsu, Mengdi Liu, Caixia Shen, and Bing Zhang. *Pollution Mitigation and Productivity: Evidence from Chinese Manufacturing Firms*. Working Paper, 2020.

Graff Zivin, Joshua, and Matthew Neidell. "The impact of pollution on worker productivity." *American Economic Review* 102, no. 7 (2012): 3652-73.

Greenstone, Michael. "The impacts of environmental regulations on industrial activity: Evidence from the 1970 and 1977 clean air act amendments and the census of manufactures." *Journal of Political Economy* 110, no. 6 (2002): 1175-1219.

Greenstone, Michael, and Rema Hanna. "Environmental regulations, air and water pollution, and infant mortality in India." *American Economic Review* 104, no. 10 (2014): 3038-72.

Greenstone, Michael, Guojun He, Shanjun Li, and Eric Yongchen Zou. "China's war on pollution: Evidence from the first 5 years." *Review of Environmental Economics and Policy* 15, no. 2 (2021): 281-299.

Greenstone, Michael, Guojun He, Ruixue Jia, and Tong Liu. "Can Technology Solve the Principal-Agent Problem? Evidence from China's War on Air Pollution." *American Economic Review: Insights* 4, no. 1 (2022): 54-70.

Greenstone, Michael, and B. Kelsey Jack. "Envirodevonomics: A research agenda for an emerging field." *Journal of Economic Literature* 53, no. 1 (2015): 5-42.

Greenstone, Michael, John A. List, and Chad Syverson. *The effects of environmental regulation on the competitiveness of US manufacturing*. No. w18392. National Bureau of Economic Research, 2012.

Greenstone, Michael, Janhavi Nilekani, Rohini Pande, Nicholas Ryan, Anant Sudarshan, and Anish Sugathan. "Lower pollution, longer lives: life expectancy gains if India reduced particulate matter pollution." *Economic and Political Weekly* (2015): 40-46.

Greenstone, Michael, Rohini Pande, Nicholas Ryan, and Anant Sudarshan, 2020. "Continuous Emissions Monitoring Systems (CEMS) in India." *3ie Impact Evaluation Report* 111. New Delhi: International Initiative for Impact Evaluation (3ie).

Grossman, Guy, Melina R. Platas, and Jonathan Rodden. "Crowdsourcing accountability: ICT for service delivery." *World Development* 112 (2018): 74-87.

He, Guojun, Shaoda Wang, and Bing Zhang. "Watering down environmental regulation in China." *The Quarterly Journal of Economics* 135, no. 4 (2020): 2135-2185.

Henderson, J. Vernon. "Effects of air quality regulation." *The American Economic Review* (1996): 789-813.

Isen, Adam, Maya Rossin-Slater, and W. Reed Walker. "Every breath you take—every dollar you'll make: The long-term consequences of the clean air act of 1970." *Journal of Political Economy* 125, no. 3 (2017): 848-902.

Ito, Koichiro, and Shuang Zhang. "Willingness to pay for clean air: Evidence from air purifier markets in China." *Journal of Political Economy* 128, no. 5 (2020): 1627-1672.

Jia, Ruixue. "Pollution for promotion." *21st Century China Center Research Paper* 2017-05 (2017).

Jing, Jun. "Environmental protests in rural China." *Chinese society: change, conflict and resistance* (2000): 143-60.

Kahn, Matthew E., Pei Li, and Daxuan Zhao. "Water pollution progress at borders: the role of changes in China's political promotion incentives." *American Economic Journal: Economic Policy* 7, no. 4 (2015): 223-42.

Kahn, Matthew E., and Erin T. Mansur. "Do local energy prices and regulation affect the geographic concentration of employment?." *Journal of Public Economics* 101 (2013): 105-114.

Konar, Shameek, and Mark A. Cohen. "Information as regulation: The effect of community right to know laws on toxic emissions." *Journal of Environmental Economics and Management* 32, no. 1 (1997): 109-124.

Kremer, Michael, Jessica Leino, Edward Miguel, and Alix Peterson Zwane. "Spring cleaning: Rural water impacts, valuation, and property rights institutions." *The Quarterly Journal of Economics* 126, no. 1 (2011): 145-205.

Lipscomb, Molly, and Ahmed Mushfiq Mobarak. "Decentralization and pollution spillovers: evidence from the re-drawing of county borders in Brazil." *The Review of Economic Studies* 84, no. 1 (2016): 464-502.

List, John A., and Daniel M. Sturm. "How elections matter: Theory and evidence from environmental policy." *The Quarterly Journal of Economics* 121, no. 4 (2006): 1249-1281.

Lorentzen, Peter L. "Regularizing rioting: Permitting public protest in an authoritarian regime." *Quarterly Journal of Political Science* 8, no. 2 (2013): 127-158.

Mansuri, Ghazala, and Vijayendra Rao. "Community-based and-driven development: A critical review." *The World Bank Research Observer* 19, no. 1 (2004): 1-39.

Mattozzi, Andrea, and Antonio Merlo. "The transparency of politics and the quality of politicians." *American Economic Review* 97, no. 2 (2007): 311-315.

Mei, Yixin, and Yanhui Wu. "Social Media and Government Responsiveness: Evidence from Vaccine Procurement in China." Working Paper (2022).

Olken, Benjamin A. "Monitoring corruption: evidence from a field experiment in Indonesia." *Journal of Political Economy* 115, no. 2 (2007): 200-249.

Qian, Yingyi, and Barry R. Weingast. "Federalism as a commitment to reserving market incentives." *Journal of Economic perspectives* 11, no. 4 (1997): 83-92.

Qin, Bei, David Strömberg, and Yanhui Wu. "Social media and collective action in China." (2021).

Reinikka, Ritva, and Jakob Svensson. "The power of information in public services: Evidence from education in Uganda." *Journal of Public Economics* 95, no. 7-8 (2011): 956-966.

Ryan, Stephen P. "The costs of environmental regulation in a concentrated industry." *Econometrica* 80, no. 3 (2012): 1019-1061.

Steinert-Threlkeld, Zachary C. "Spontaneous collective action: Peripheral mobilization during the Arab Spring." *American Political Science Review* 111, no. 2 (2017): 379-403.

Steinhardt, H. Christoph, and Fengshi Wu. "In the name of the public: Environmental protest and the changing landscape of popular contention in China." *The China Journal* 75, no. 1 (2016): 61-82.

Stiglitz, Joseph E. "Participation and development: Perspectives from the comprehensive development paradigm." *Review of Development eEconomics* 6, no. 2 (2002): 163-182.

United Nations Environment Program. "Environmental rule of law: First global report." (2019).

Walker, W. Reed. "The transitional costs of sectoral reallocation: Evidence from the clean air act and the workforce." *The Quarterly Journal of Economics* 128, no. 4 (2013): 1787-1835.

Wang, Shaoda, and Zenan Wang. "The Environmental and Economic Consequences of Internalizing Border Spillovers." (2020).

World Bank. *World development report 2004: making services work for poor people*. The World Bank, 2004.

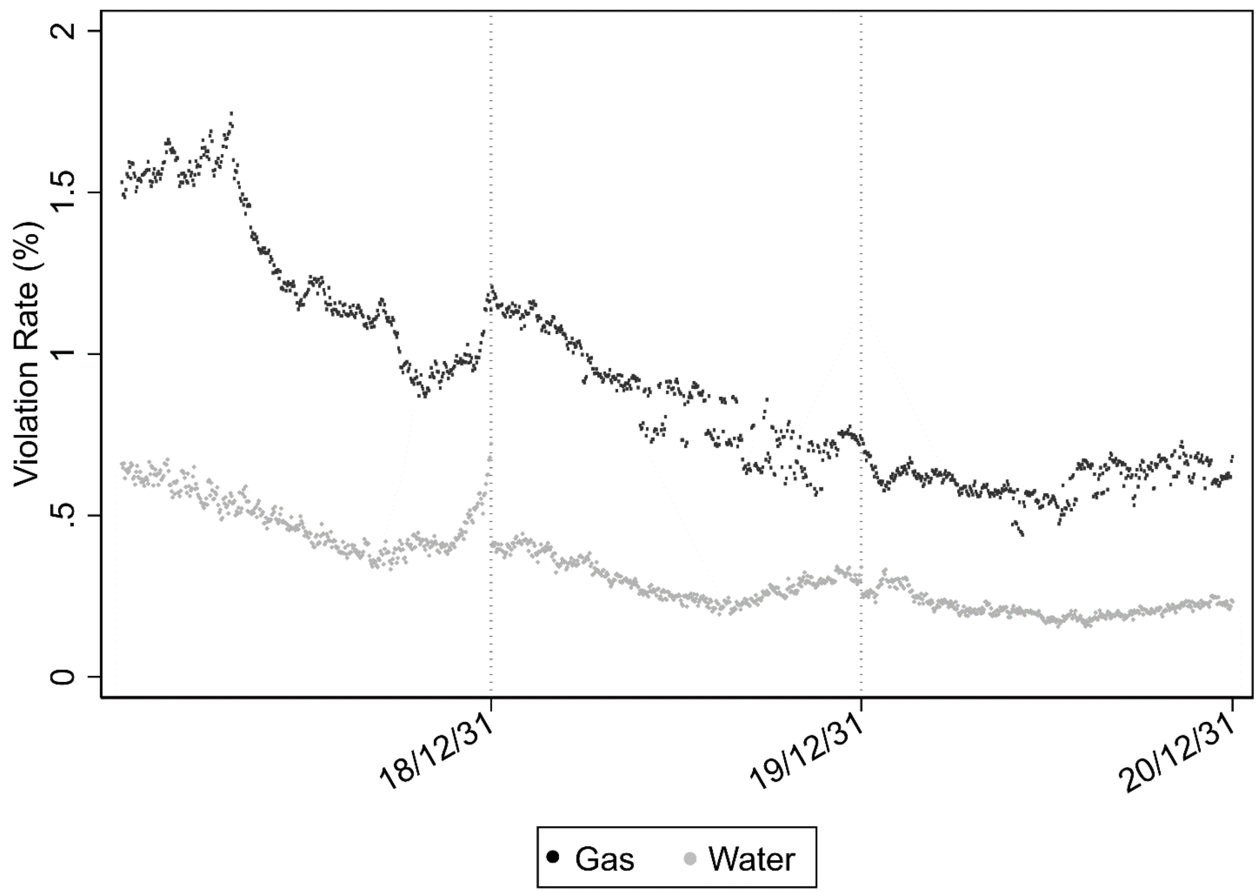
Wu, Wenqi, Wenwen Wang, Lu Zhang, Qiaoyu Wang, Lujing Wang, and Ming Zhang. "Does the public haze pollution concern expressed on online platforms promoted pollution control?– Evidence from Chinese online platforms." *Journal of Cleaner Production* 318 (2021): 128477.

Xu, Chenggang. "The fundamental institutions of China's reforms and development." *Journal of Economic Literature* 49, no. 4 (2011): 1076-1151.

Yanagizawa-Drott, David, Maria Petrova, and Ruben Enikolopov. *Echo Chambers: Does Online Network Structure Affect Political Polarization?*. Mimeo, 2021.

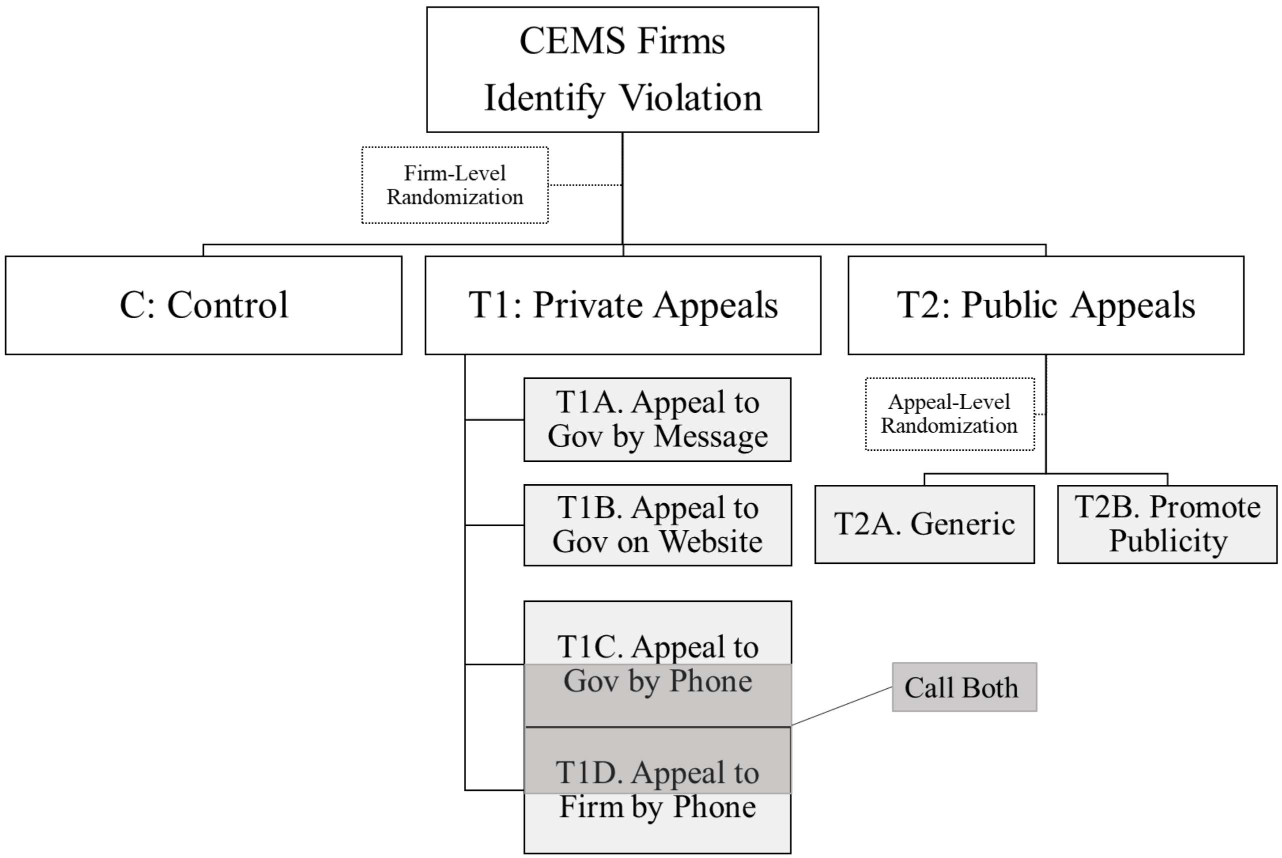
Zhuravskaya, Ekaterina, Maria Petrova, and Ruben Enikolopov. "Political effects of the internet and social media." *Annual Review of Economics* 12 (2020): 415-438.

Figure 1. Violation Rates over Time



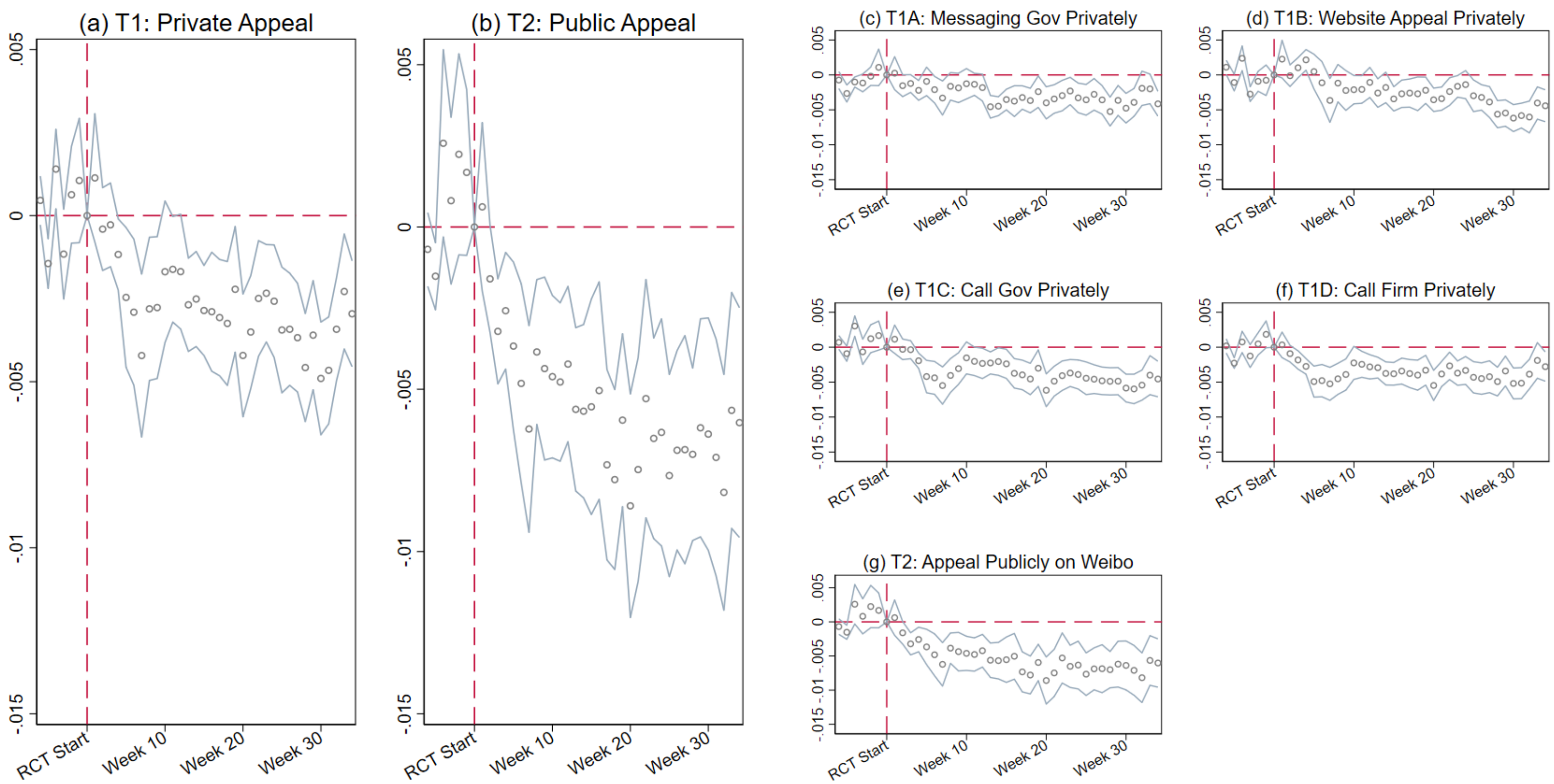
Note: This figure plots the daily trends of waste gas and water emission violations in the CEMS data, between 2018 and 2021. The Y-axis represents the ratio of CEMS firms' stacks that violated the gas/water emission standard on any given day.

Figure 2. Experimental Design



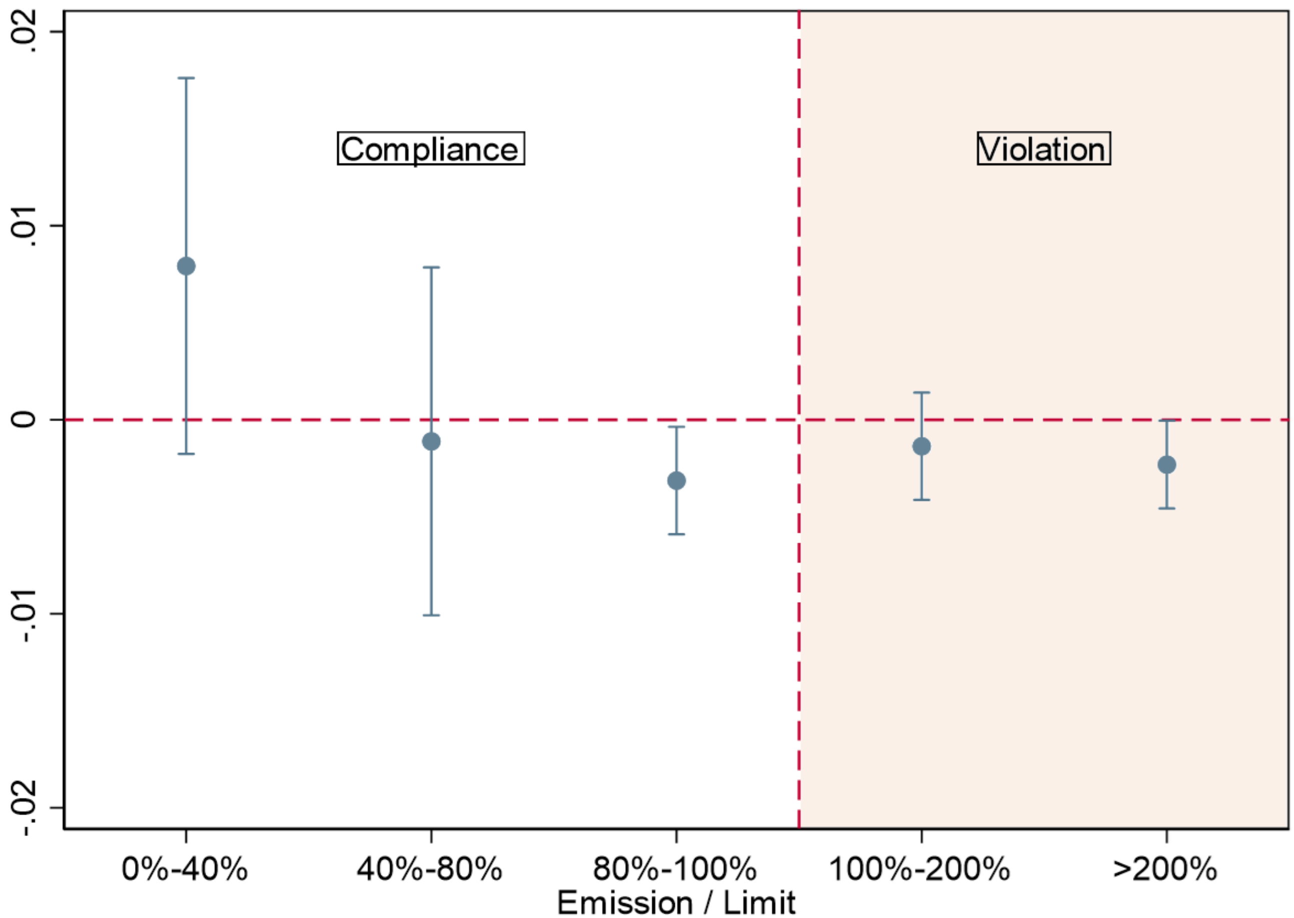
Note: This figure illustrates our experimental design, in which each CEMS firm is randomly assigned to one of seven different arms.

Figure 3. Event Studies



Note: This figure presents coefficients and 90% confidence intervals on Treatment*Week interactions from regressions of violation on Treatment*Week, firm FE, and week FE. Standard errors are clustered two-way by prefecture and week.

Figure 4. Effects of Public Appeals on Excessive Violations



Note: In this figure, we visualize how public pollution appeals shift the distribution of emission concentrations. We divide each firm's SO2 (COD) emission concentration on a given day by the SO2 (COD) emission limit for this firm set by the MEE, and generate six bins based on this standardized emission variable. We regress the dummy variable for each bin on our treatment variables, using the same baseline specification in equation (1), and plot the coefficients and 90% CIs from these regressions. We control for firm FE and province-by-day FE. Standard errors are clustered two-way by prefecture and week.

Table 1. Summary of Basic Facts about the Experiment

	(1)	(2)	(3)	(4)
Panel A. Experimental Environment				
	Number of Prefectures Covered	Number of CEMS Firms Covered	Number of Appeals Filed by Other Citizens During the Experiment	Number of Appeals Filed by Other Citizens about CEMS Firms During the Experiment
	333	24,620	271,859	5,478
Panel B. Experimental Team				
	Number of Partnering NGOs	Number of Citizen Volunteers on any Given Day	Number of Weibo Accounts Involved in Appeals	Number of Environmental Science Graduate Students Verifying Violations
	3	15	120	12
Panel C. Experimental Implementation				
	Number of Violations During Experiment According to CEMS Raw data	Number of Violations During Experiment Verified by Research Team	Number of Appeals Filed by Research Team	Number of Formal Responses to Appeals Filed by Research Team
	12,596	5,366	2,941	1,161

Note: This table reports the background and the implementation of our experiment. Our experiment started on May 6, 2020, and ended on December 31, 2020. Information on the number of appeals filed by other citizens is obtained from the MEE's administrative record, which we matched to the CEMS sample. The three partnering NGOs, who prefer to remain anonymous, helped us recruit and organize citizen environmental volunteers, maintaining 15 individuals ready to file appeals on any given day. The number of verified appeals is lower than the number of appeals in the CEMS raw data, since we were conservative and excluded case that might be driven by outliers or mechanical errors. The number of appeals filed is lower than the total number of violations verified by the research team, because we did not appeal against violations committed by the control firms, nor did we file appeals repeatedly within a week about the same firm.

Table 2. Balance Test

	(1)	(2)	(3)	(4)	(5)	(6)
	Control	Private Appeals				Public Appeals
		Messaging	Website	Call Gov	Call Firm	Weibo
	C	T1A-C	T1B-C	T1C-C	T1D-C	T2-C
Panel A: Outcomes						
SO2 Violations	0.217	0.011	0.030	0.022	0.052	0.082
	(2.202)	(0.052)	(0.072)	(0.052)	(0.058)	(0.078)
COD Violations	0.095	0.014	0.006	0.001	0.017	0.036
	(0.862)	(0.023)	(0.023)	(0.020)	(0.024)	(0.025)
Total Violations	0.739	0.084	0.034	0.000	0.120	0.181
	(4.927)	(0.125)	(0.128)	(0.128)	(0.136)	(0.156)
SO2	135.2	-21.7	-14.5	-19.1	-37.0	-8.4
Concentrations	(982.0)	(21.6)	(15.8)	(22.9)	(33.5)	(18.2)
COD	57.6	1.3	3.8	1.8	2.0	0.6
Concentrations	(69.1)	(2.2)	(3.1)	(3.5)	(2.4)	(3.6)
Gas Penalty	0.008	0.001	-0.003	-0.000	0.002	-0.003
	(0.146)	(0.004)	(0.003)	(0.002)	(0.004)	(0.003)
Water Penalty	0.001	0.001	0.002	0.003	0.002	0.002
	(0.055)	(0.002)	(0.002)	(0.002)	(0.002)	(0.002)
Total Penalty	0.009	0.002	-0.002	0.003	0.004	-0.001
	(0.156)	(0.004)	(0.003)	(0.003)	(0.004)	(0.003)
Frequent	0.055	-0.004	0.008	0.011	0.005	0.008
Violators	(0.228)	(0.008)	(0.008)	(0.007)	(0.006)	(0.008)
Panel B: Industries						
Mining Industry	0.024	0.001	-0.004	0.001	-0.002	0.003
	(0.154)	(0.004)	(0.006)	(0.005)	(0.004)	(0.006)
Manufacturing	0.730	0.015	0.018	0.021	0.012	0.019
& Power Plants	(0.444)	(0.012)	(0.015)	(0.014)	(0.011)	(0.015)
Sewage	0.166	-0.017*	-0.015	-0.007	-0.007	-0.012
Treatment	(0.372)	(0.010)	(0.012)	(0.013)	(0.010)	(0.013)
Others	0.080	0.001	0.001	-0.015	-0.003	-0.010
	(0.272)	(0.007)	(0.010)	(0.010)	(0.007)	(0.009)

Note: This table reports balance tests across different experimental arms using data from the pre-treatment period. For outcomes on pollution concentrations and violations, the sample includes eight weeks before the start of the experiment. For pollution penalties, the sample is from 2019. For frequent violators, we define a firm as a frequent violator if it violated more than ten times in 2019. Column 1 reports the means and standard deviations of the control arm. Columns 2-6 report the difference between each appeal arm and the control arm. We control for province FE. Standard errors are clustered at the prefecture level. * $p < 0.10$, ** $p < 0.05$, *** $p < 0.01$

Table 3. Pollution Appeals and Firm Violations / Emission Concentrations

	(1a)	(1b)	(2a)	(2b)	(3a)	(3b)
	Violation	Violation	SO2	SO2	COD	COD
Private Appeals (T1*Post)	-0.003***	-0.002**	-5.6	-5.9	-0.3	-0.4
	(0.001)	(0.001)	(3.6)	(3.6)	(0.9)	(0.8)
Public Appeals (T2*Post)	-0.006***	-0.006***	-15.8***	-16.2***	-2.1*	-2.2*
	(0.002)	(0.001)	(4.4)	(4.4)	(1.2)	(1.2)
H0: T1<T2	P=0.01	P=0.00	P=0.01	P=0.02	P=0.03	P=0.03
Control Mean	0.009	0.009	132.5	132.5	59.1	59.1
Control SD	0.096	0.096	539.5	539.5	78.8	78.8
Firm FE	Yes	Yes	Yes	Yes	Yes	Yes
Day FE	Yes		Yes		Yes	
Province by Day FE		Yes		Yes		Yes
Observations	7,100,881	7,100,881	2,216,208	2,216,208	2,459,622	2,459,622

Note: This table reports the regression results from estimating Equation (1). In Columns (1a) and (1b), we use firm-day level data, and the outcome variable is a dummy variable that equals 1 if the firm violates an emission standard on that day, and zero otherwise; in Columns (2a) and (2b), we use pipe-day level data, and the outcome variable is the daily average emission concentration of SO2 (mg/m3); in Columns (3a) and (3b), we use pipe-day level data, and the outcome variable is the daily average emission concentration of COD (mg/L). For each outcome, in the column "a", we control for firm FE and day FE; in the columns "b", we control for firm FE and province-by-day FE. Standard errors are clustered two-way by prefecture and week. * $p < 0.10$, ** $p < 0.05$, *** $p < 0.01$

Table 4. Heterogeneity Analyses on Firm Violations and Emission Concentrations

	(1a) Violation	(1b) SO_2	(1c) COD	(2a) Violation	(2b) SO_2	(2c) COD	(3a) Violation	(3b) SO2	(3c) COD
Private Appeals (T1*Post)	-0.002*	-6.9*	-0.3	-0.002	-7.1	-0.1	-0.000	-7.9	0.2
	(0.001)	(4.0)	(1.0)	(0.001)	(4.4)	(1.0)	(0.001)	(5.1)	(0.8)
Public Appeals (T2*Post)	-0.005***	-19.4***	-2.3	-0.006***	-18.9***	-2.2	-0.001	-15.7***	-2.0
	(0.002)	(5.1)	(1.4)	(0.002)	(5.3)	(1.6)	(0.001)	(5.5)	(1.6)
Private Appeals (T1*Post)*SOE	-0.003	8.2	0.6						
	(0.004)	(15.0)	(2.7)						
Public Appeals (T2*Post)*SOE	-0.005	24.4	1.9						
	(0.005)	(17.0)	(2.9)						
Post*SOE	0.003	-6.9	0.1						
	(0.004)	(6.3)	(2.3)						
Private Appeals (T1*Post)*Final				-0.002	7.8	-1.1			
				(0.002)	(4.8)	(1.5)			
Public Appeals (T2*Post)*Final				0.002	10.1*	-0.3			
				(0.003)	(5.9)	(2.5)			
Post*Final				0.002	-3.2	2.7**			
				(0.002)	(4.9)	(1.3)			
Private Appeals (T1*Post)*Frequent							-0.013*	9.4	3.0
							(0.006)	(7.7)	(2.7)
Public Appeals (T2*Post)*Frequent							-0.030***	-2.0	4.9
							(0.009)	(12.8)	(3.2)
Post*Frequent							-0.028***	-5.7	-5.1*
							(0.007)	(4.6)	(2.7)
Firm FE	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes
Province by Day FE	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes
Observations	6,016,662	1,971,513	2,128,655	6,016,662	1,971,513	2,128,655	5,827,579	1,887,624	1,998,089

Note: This table reports the results for heterogeneity analyses. In Columns "a", we use firm-day level data, and the outcome variable is a dummy variable that equals 1 if the firm violates an emission standard on that day, and zero otherwise; in Columns "b", we use pipe-day level data, and the outcome variable is the daily average emission concentration of SO2 (mg/m3); in Columns "c", we use pipe-day level data, and the outcome variable is the daily average emission concentration of COD (mg/L). SOE is a dummy variable that equals 1 if the firm's majority shareholder is the government. Final is a dummy variable indicating whether the firm produces final good instead of intermediate good based on its industry code. Frequent is a dummy variable that equals 1 if the firm committed pollution violations in the seven weeks prior to the experiment. We control for firm FE and province-by-day FE. Standard errors are clustered two-way by prefecture and week. * $p < 0.10$, ** $p < 0.05$, *** $p < 0.01$

Table 5. Pollution Appeals and Firm Violations and Emission Concentrations by Arms

	(1a) Violation	(1b) Violation	(2a) SO_2	(2b) SO_2	(3a) COD	(3b) COD
Messaging Gov Privately (T1A*Post)	-0.002*	-0.002*	-3.0	-3.4	-0.1	-0.1
	(0.001)	(0.001)	(8.1)	(8.0)	(1.1)	(1.1)
Website Appeal Privately (T1B*Post)	-0.002**	-0.001	-4.8	-4.7	-0.3	-0.4
	(0.001)	(0.001)	(5.6)	(5.6)	(1.1)	(1.0)
Call Gov Privately (T1C*Post)	-0.003***	-0.002*	-4.0	-4.6	-0.7	-0.6
	(0.001)	(0.001)	(5.8)	(5.6)	(0.8)	(0.8)
Call Firm Privately (T1D*Post)	-0.001	-0.001	-4.7	-5.1	-0.6	-0.6
	(0.001)	(0.001)	(4.3)	(4.4)	(1.2)	(1.2)
Call Gov*Call Firm (T1C*TID*Post)	-0.001	-0.001	-1.9	-1.5	1.4	1.3
	(0.002)	(0.001)	(7.8)	(7.7)	(1.4)	(1.4)
Appeal Publicly on Weibo (T2*Post)	-0.006***	-0.006***	-15.8***	-16.3**	-2.1*	-2.2*
	(0.002)	(0.001)	(4.4)	(4.5)	(1.23)	(1.2)
H0: T1A=T1B=T1C=T1D	P=0.35	P=0.46	P=1.00	P=1.00	P=0.94	P=0.93
Control Mean	0.009	0.009	132.5	132.5	59.1	59.1
Control SD	0.096	0.096	539.5	539.5	78.8	78.8
Firm FE	Yes	Yes	Yes	Yes	Yes	Yes
Day FE	Yes		Yes		Yes	
Province by Day FE		Yes		Yes		Yes
Observations	7,100,881	7,100,881	2,216,208	2,216,208	2,459,622	2,459,622

Note: This table reports the regression results from estimating Equation (1). In Columns (1a) and (1b), we use firm-day level data, and the outcome variable is a dummy variable that equals 1 if the firm violates an emission standard on that day, and zero otherwise; in Columns (2a) and (2b), we use pipe-day level data, and the outcome variable is the daily average emission concentration of SO2 (mg/m3); in Columns (3a) and (3b), we use pipe-day level data, and the outcome variable is the daily average emission concentration of COD (mg/L). For each outcome, in the column "a", we control for firm FE and day FE; in the columns "b", we control for firm FE and province-by-day FE. Standard errors are clustered two-way by prefecture and week. * $p < 0.10$, ** $p < 0.05$, *** $p < 0.01$

Table 6. Social Media Publicity and Government Responsiveness

	(1a) Whether Respond	(1b) Whether Respond	(2a) Response Length	(2b) Response Length	(3a) Onsite Audit	(3b) Onsite Audit
Visibility Promotion (T2B)	0.06*	0.06**	34.6**	33.8**	0.04*	0.05**
	(0.03)	(0.03)	(13.4)	(13.4)	(0.02)	(0.02)
Control Mean	0.16	0.16	33.1	33.1	0.07	0.07
Control SD	0.36	0.36	117.9	117.9	0.26	0.26
Month FE	Yes	Yes	Yes	Yes	Yes	Yes
Province FE		Yes		Yes		Yes
Observations	662	658	662	658	662	658

Note: This table reports the regression results for public Weibo appeals on local government responsiveness. We use the sample of firms in the public Weibo appeal to government arm. The unit of analysis is each Weibo appeal. Whether respond is a dummy variable that equals 1 if the government replies to our Weibo appeal, and 0 otherwise; response length is the word count of the government's Weibo reply to our appeal, which is counted as zero if there is no response; onsite audit is a dummy variable that equals 1 if the government replies to our Weibo appeal with proof of an onsite investigation, and 0 otherwise. For each outcome, in the column "a", we control for month FE; in the column "b", we control for month FE and province FE. * $p < 0.10$, ** $p < 0.05$, *** $p < 0.01$

Table 7. Pollution Appeals and Ambient Air Pollution Levels

	(1a)	(1b)
	SO_2	SO_2
High Intensity Region*Post	-0.36*	-0.37*
	(0.20)	(0.19)
Control Mean	10.06	10.06
Control SD	6.59	6.59
City FE	Yes	Yes
Day FE	Yes	
Province by Day FE		Yes
Observations	90,603	89,443

Note: This table reports the regression results using ambient SO2 air quality data from more than 1,600 air quality monitoring stations in China. The unit of analysis is prefecture-day. In Column (1a), we control for city FE and day FE; in Column (1b), we control for city FE and province-by-day FE. Standard errors are clustered two-way by prefecture and week. * $p < 0.10$, ** $p < 0.05$, *** $p < 0.01$

Table 8. General Equilibrium Effects of Pollution Appeals

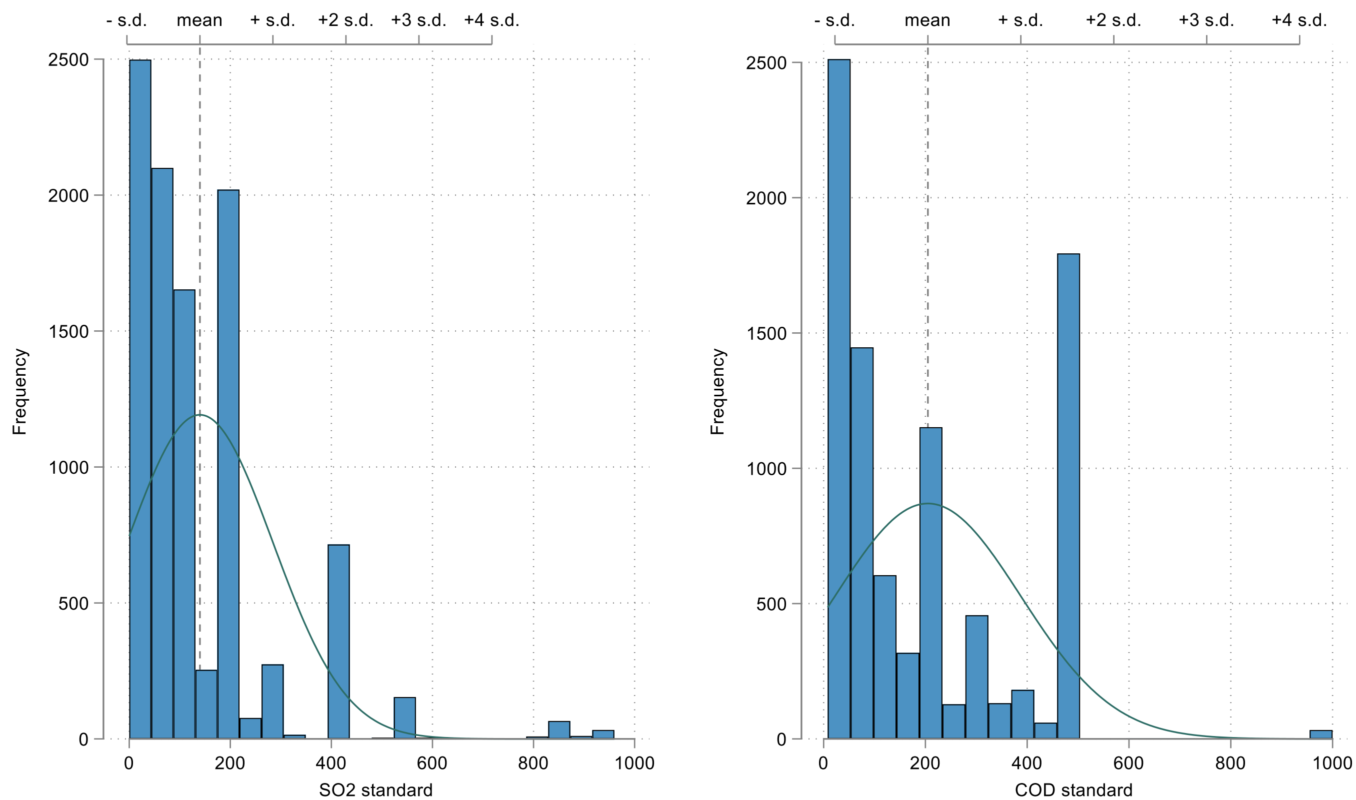
	(1a)	(1b)	(2a)	(2b)	(3a)	(3b)
	Violation	Violation	SO2	SO2	COD	COD
Panel A: Control Group						
High Intensity*Post	0.000	0.001	-5.3	-9.0	1.5	1.9
	(0.002)	(0.002)	(5.6)	(7.6)	(2.1)	(1.9)
Observations	1,024,692	1,024,692	296,604	296,604	356,265	356,265
Panel B: Treatment Group						
High Intensity*Post	-0.003*	-0.002*	-0.6	0.8	-0.7	-0.1
	(0.001)	(0.001)	(5.4)	(5.8)	(1.7)	(1.6)
Observations	6,062,153	6,062,153	1,919,513	1,919,513	2,103,337	2,103,337
Control Mean	0.009	0.009	132.2	132.2	58.9	58.9
Control SD	0.093	0.093	536.4	536.4	77.0	77.0
Firm FE	Yes	Yes	Yes	Yes	Yes	Yes
Day FE	Yes		Yes		Yes	
Province by Day FE		Yes		Yes		Yes

Note: This table reports the results of general equilibrium analyses. Panels A and B report the impact of assignment to the 95% prefecture group, relative to the 70% group for the control and treatment groups. In Columns (1a) and (1b), we use firm-day level data, and the outcome variable is a dummy variable that equals 1 if the firm violates an emission standard on that day, and zero otherwise; in Columns (2a) and (2b), we use pipe-day level data, and the outcome variable is the daily average emission concentration of SO2 (mg/m3); in Columns (3a) and (3b), we use pipe-day level data, and the outcome variable is the daily average emission concentration of COD (mg/L). For each outcome, in the column "a", we control for firm FE and day FE; in the columns "b", we control for firm FE and province-by-day FE. Standard errors are clustered two-way by prefecture and week. * $p < 0.10$, ** $p < 0.05$, *** $p < 0.01$

Online Appendix

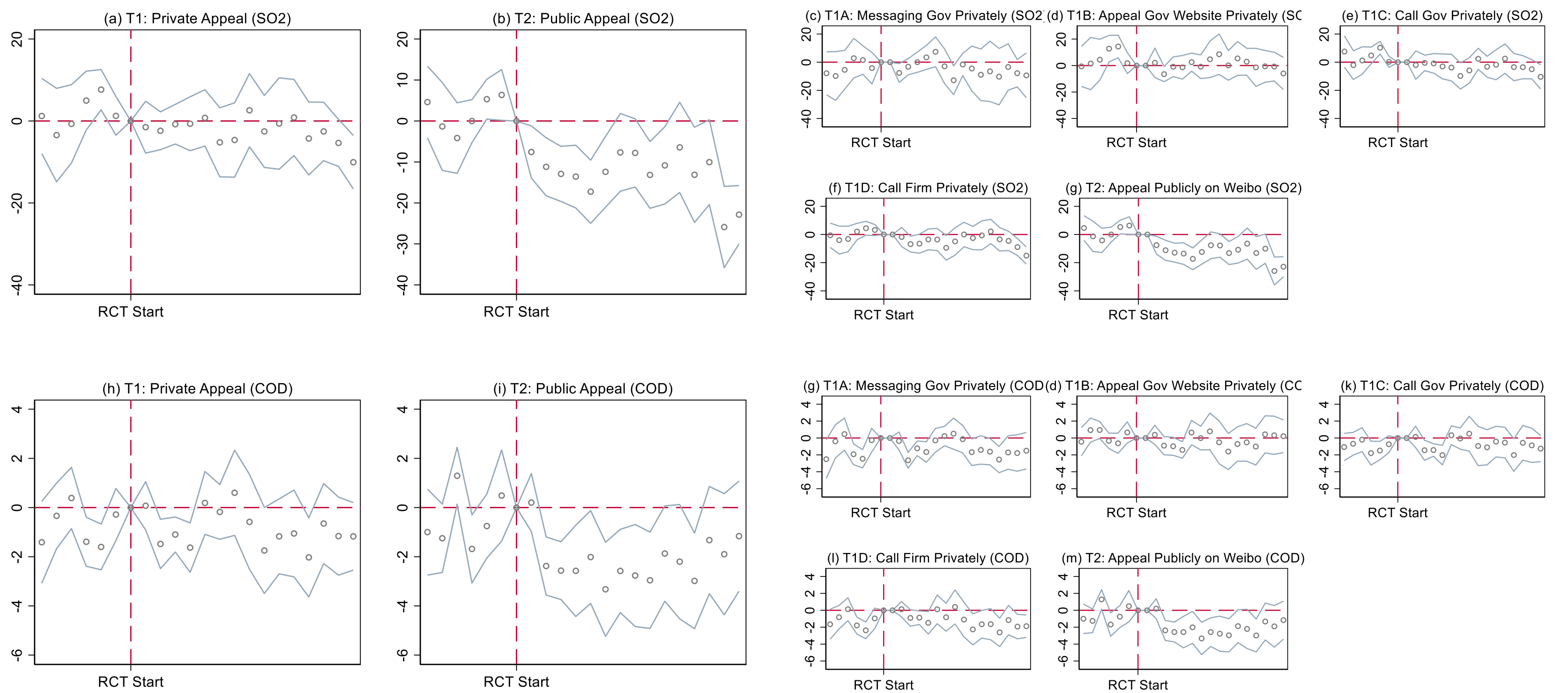
APPENDIX A: FIGURES AND TABLES

Figure A1. Distribution of Pollution Emission Standards



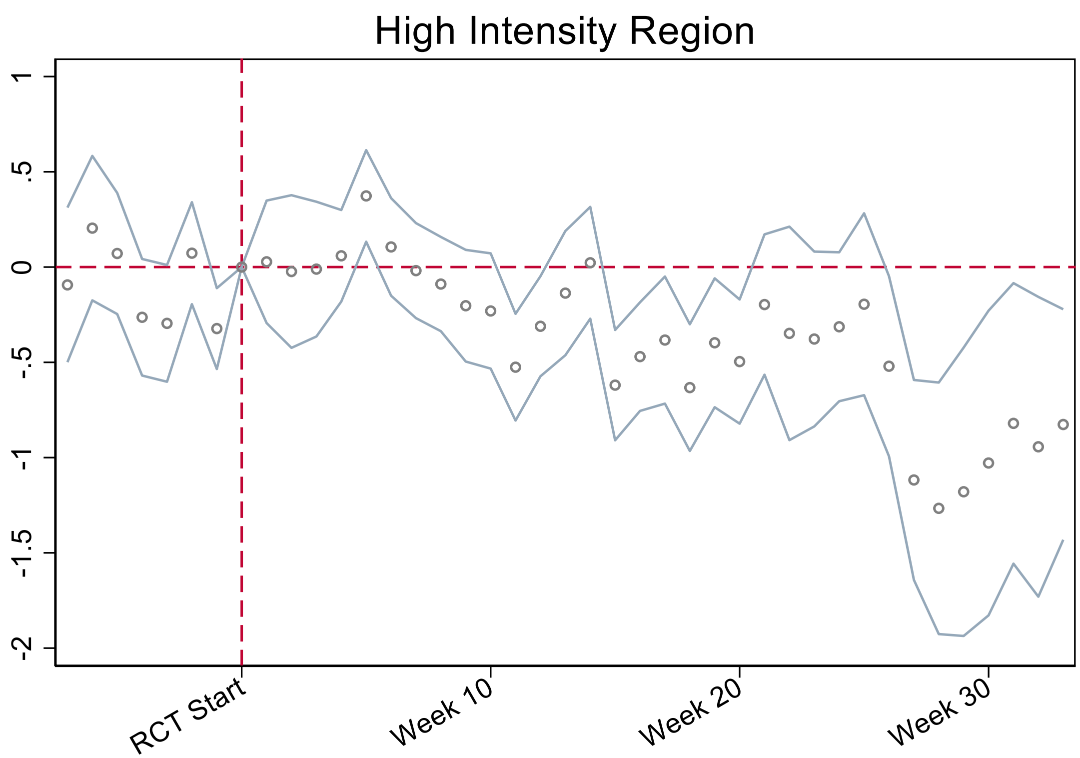
Note: This figure presents the distribution of SO2 and COD emission standards. The units for SO2 standards are mg/m3, and the units for COD standards are mg/L.

Figure A2. Event Studies for Public and Private Appeals on Emission Concentrations



Note: This figure presents coefficients and 90% confidence intervals on Treatment*Biweek interactions from regressions of concentration on Treatment *Biweek, firm FE, and biweek FE. Standard errors are clustered two-way by prefecture and biweek.

Figure A3. Event Studies for High Intensity Region on Ambient Air Pollution Levels



Note: This figure presents coefficients and 90% confidence intervals on High Intensity*Week interactions from regressions of ambient SO2 air quality on High Intensity*Week, city FE, and province-by-week FE. Standard errors are clustered two-way by prefecture and week.

Table A1. Industry Distribution

	(1)	(2)	(3)	(4)	(5)	(6)
	Control	Private Appeals				Public Appeals
		Messaging	Website	Call Gov	Call Firm	Weibo
	C	T1A	T1B	T1C	T1D	T2
Water production and sewage treatment plant (46)	16.55%	15.00%	17.07%	16.80%	17.03%	17.40%
Electricity and heat production and supply (44)	12.00%	11.93%	11.88%	12.18%	11.26%	12.26%
Chemical raw materials and products (26)	6.20%	6.89%	9.16%	9.87%	8.64%	9.99%
Textile printing and dyeing (17)	9.68%	9.34%	9.16%	8.50%	8.44%	8.55%
Non-metallic mineral products (30)	6.63%	7.19%	7.64%	8.32%	7.79%	7.98%
Agri-food processing (13)	3.49%	3.57%	5.03%	4.16%	3.65%	4.27%
Paper products (22)	4.79%	5.67%	4.56%	4.62%	4.84%	4.22%
Ferrous metal smelting and rolling processing (31)	4.99%	4.79%	3.30%	3.76%	4.07%	3.40%
Pharmaceutical manufacturing (27)	2.86%	2.44%	2.88%	3.02%	3.27%	3.09%
Petroleum, coal and other fuel processing (25)	2.47%	2.40%	2.72%	3.20%	2.67%	2.99%
Metal products (33)	3.73%	2.54%	3.51%	2.94%	3.32%	2.73%
Liquor, beverage and refined tea manufacturing (15)	1.31%	2.20%	2.41%	2.49%	2.60%	2.47%
Food manufacturing (14)	1.36%	1.76%	2.04%	1.85%	1.67%	1.65%
Coal mining and washing (6)	1.40%	1.52%	1.26%	1.60%	1.42%	1.60%
Electronic equipment manufacturing (39)	1.65%	1.03%	1.20%	1.12%	1.10%	1.60%
Leather, fur, feathers and their products (19)	2.23%	2.49%	1.20%	1.57%	1.82%	1.34%
Total	81.3%	80.7%	85.0%	86.0%	83.6%	85.5%

Note: This table presents the industries that make up the highest percentage of T2. Other industries are also included in the sample.

Table A2. Pollution Appeals and Verified Environmental Violations

	(1a) Violation	(1b) Violation
Panel A. Impacts of Private and Public Appeals		
Private Appeals (T1*Post)	-0.002***	-0.002**
	(0.001)	(0.001)
Public Appeals (T2*Post)	-0.005***	-0.004***
	(0.001)	(0.001)
H0: T1<T2	P=0.009	P=0.005
Panel B. Impacts of Private and Public Appeals		
Messaging Gov Privately (T1A*Post)	-0.002**	-0.002**
	(0.001)	(0.001)
Appeal Gov Website Privately (T1B*Post)	-0.003***	-0.002**
	(0.001)	(0.001)
Call Gov Privately (T1C*Post)	-0.002	-0.001
	(0.001)	(0.001)
Call Firm Privately (T1D*Post)	-0.001	-0.001
	(0.001)	(0.001)
Call Gov*Call Firm (T1C*TID*Post)	-0.001	-0.001
	(0.001)	(0.001)
Appeal Publicly on Weibo (T2*Post)	-0.005***	-0.004***
	(0.001)	(0.001)
H0: T1A=T1B=T1C=T1D	P=0.25	P=0.48
Control Mean	0.007	0.007
Control SD	0.083	0.083
Firm FE	Yes	Yes
Day FE	Yes	
Province by Day FE		Yes
Observations	7,100,881	7,100,881

Note: This table reports the regression results from estimating Equation (1), excluding cases with minimal levels of measured air flows as these may be instances when the plant is not operating. Violation is a dummy variable that equals 1 if the firm violates an emission standard on that day, and zero otherwise. In Column (1a), we control for firm FE and day FE. In Column (1b), we control for firm FE and province-by-day FE. Standard errors are clustered two-way by prefecture and week. * p < 0.10, ** p < 0.05, *** p < 0.01

Table A3. Robustness Checks using Alternative Clusters

	(1a) Violation	(1b) Violation	(2a) SO2	(2b) SO2	(3a) COD	(3b) COD
Panel A. Prefecture by Arm Cluster						
Private Appeals	-0.003***	-0.002***	-5.6**	-5.9**	-0.3***	-0.4**
(T1*Post)	(0.000)	(0.000)	(1.8)	(2.0)	(0.0)	(0.1)
Public Appeals	-0.006***	-0.006***	-15.8***	-16.2***	-2.1***	-2.2***
(T2*Post)	(0.000)	(0.000)	(0.4)	(1.5)	(0. 0)	(0.3)
H0: T1<T2	P=0.00	P=0.00	P=0.00	P=0.00	P=0.00	P=0.00
Panel B. Prefecture Cluster						
Private Appeals	-0.003***	-0.002**	-5.6	-5.9	-0.3	-0.4
(T1*Post)	(0.001)	(0.001)	(3.7)	(3.8)	(0.9)	(0.9)
Public Appeals	-0.006***	-0.006***	-15.8***	-16.2***	-2.1	-2.2*
(T2*Post)	(0.002)	(0.001)	(4.6)	(4.8)	(1.3)	(1.2)
H0: T1<T2	P=0.01	P=0.00	P=0.02	P=0.02	P=0.04	P=0.04
Control Mean	0.009	0.009	132.5	132.5	59.1	59.1
Control SD	0.096	0.096	539.5	539.5	78.8	78.8
Firm FE	Yes	Yes	Yes	Yes	Yes	Yes
Day FE	Yes		Yes		Yes	
Province by Day FE		Yes		Yes		Yes
Observations	7,100,881	7,100,881	2,216,208	2,216,208	2,459,622	2,459,622

Note: This table reports the regression results from estimating Equation (1). In Columns (1a) and (1b), we use firm-day level data, and the outcome variable is a dummy variable that equals 1 if the firm violates an emission standard on that day, and zero otherwise; in Columns (2a) and (2b), we use pipe-day level data, and the outcome variable is the daily average emission concentration of SO2 (mg/m3); in Columns (3a) and (3b), we use pipe-day level data, and the outcome variable is the daily average emission concentration of COD (mg/L). For each outcome, in the column "a", we control for firm FE and day FE; in the columns "b", we control for firm FE and province-by-day FE. In panel A, standard errors are clustered two-way by prefecture and arm. In panel B, standard errors are clustered at the prefecture level. * $p < 0.10$, ** $p < 0.05$, *** $p < 0.01$

Table A4. Robustness Checks using Aggregated Data

	(1a) Weekly Violations	(1b) Monthly Violations
Public Appeals (T2*Post)	-0.552***	-0.537***
	(0.113)	(0.119)
Private Appeals (T1*Post)	-0.309***	-0.289***
	(0.101)	(0.102)
H0: T1<T2	P= 0.001	P=0.001
Control Mean	0.066	0.244
Control SD	0.508	1.728
Firm FE	Yes	Yes
Week FE	Yes	
Month FE		Yes
Observations	322,241	86,453

Note: This table reports the Poisson regression results from estimating Equation (1) using firm-month level data and firm-week level data. Weekly Violations measure the number of violations of the firm violates an emission standard within a week. Monthly Violations measure the number of violations of the firm violates an emission standard within a month. In Column (1a), we control for firm FE and week FE. In Column (1b), we control for firm FE and month FE. Standard errors are clustered at the prefecture level. * p < 0.10, ** p < 0.05, *** p < 0.01

Table A5. Pollution Appeals and Air Flow

	(1a)	(1b)
	log(Flow)	log(Flow)
Panel A. Impacts of Pooled Private and Public Appeals		
Private Appeals (T1*Post)	-0.027	-0.024
	(0.052)	(0.059)
Public Appeals (T2*Post)	-0.022	-0.022
	(0.047)	(0.063)
H0: T1<T2	P=0.54	P=0.51
Panel B. Impacts of the Sub-Treatments		
Messaging Gov Privately (T1A*Post)	-0.008	-0.010
	(0.062)	(0.062)
Appeal Gov Website Privately (T1B*Post)	-0.117	-0.040
	(0.071)	(0.076)
Call Gov Privately (T1C*Post)	0.005	-0.017
	(0.096)	(0.091)
Call Firm Privately (T1D*Post)	0.088	0.072
	(0.079)	(0.070)
Call Gov*Call Firm (T1C*TID*Post)	-0.203	-0.193
	(0.143)	(0.114)
Appeal Publicly on Weibo (T2*Post)	-0.022	-0.028
	(0.051)	(0.063)
H0: T1A=T1B=T1C=T1D	P=0.00	P=0.41
Control Mean	5.747	5.747
Control SD	4.452	4.452
Firm FE	Yes	Yes
Day FE	Yes	
Province by Day FE		Yes
Observations	3,979,180	3,979,180

Note: This table reports the regression results of replacing the dependent variables of Equation (1) with the logged volume of air flows using pipe-day level data. We place missing values for flow for any firms that are responsible for all flows in a province in Column (1a). In Column (1a), we control for firm FE and day FE. In Column (1b), we control for firm FE and province-by-day FE. Standard errors are clustered two-way by prefecture and week. * $p < 0.10$, ** $p < 0.05$, *** $p < 0.01$

Table A6. Impacts on Other Citizen Appeals

	(1a) Other Citizen Appeals	(1b) Other Citizen Appeals
Panel A. Impacts of Private and Public Appeals		
Private Appeals (T1*Post)	-0.0000	-0.0000
	(0.0001)	(0.0001)
Public Appeals (T2*Post)	-0.0000	-0.0001
	(0.0001)	(0.0001)
H0: T1<T2	P=0.50	P=0.42
Panel B. Impacts of the Sub-Treatments		
Messaging Gov Privately (T1A*Post)	0.0000	0.0000
	(0.0001)	(0.0001)
Appeal Gov Website Privately (T1B*Post)	0.0000	-0.0000
	(0.0001)	(0.0001)
Call Gov Privately (T1C*Post)	-0.0001	-0.0001
	(0.0002)	(0.0002)
Call Firm Privately (T1D*Post)	-0.0001	-0.0001
	(0.0001)	(0.0001)
Call Gov*Call Firm (T1C*TID*Post)	0.0002	0.0002
	(0.0002)	(0.0002)
Appeal Publicly on Weibo (T2*Post)	-0.0000	-0.0001
	(0.0001)	(0.0001)
H0: T1A=T1B=T1C=T1D	P=0.74	P=0.70
Control Mean	0.001	0.001
Control SD	0.027	0.027
Firm FE	Yes	Yes
Day FE	Yes	
Province by Day FE		Yes
Observations	7,100,881	7,100,881

Note: This table reports the regression results of replacing the dependent variables of Equation (1) with the number of appeals made by other citizens. In Column (1a), we control for firm FE and day FE. In Column (1b), we control for firm FE and province-by-day FE. Standard errors are clustered two-way by prefecture and week. * p < 0.10, ** p < 0.05, *** p < 0.01

Table A7. Pollution Appeals and Abnormal Concentrations

	(1a)	(1b)	(2a)	(2b)
	Abnormal Hour	Abnormal Hour	Abnormal Concentration	Abnormal Concentration
Panel A. Impacts of Private and Public Appeals				
Private Appeals (T1*Post)	-0.003	-0.005	0.000	-0.000
	(0.005)	(0.004)	(0.005)	(0.005)
Public Appeals (T2*Post)	-0.005	-0.011*	0.002	-0.001
	(0.006)	(0.006)	(0.006)	(0.006)
H0: T1<T2	P=0.26	P=0.04	P=0.69	P=0.46
Panel B. Impacts of the Sub-Treatments				
Messaging Gov Privately (T1A*Post)	0.002	0.003	0.003	0.003
	(0.006)	(0.005)	(0.005)	(0.005)
Appeal Gov Website Privately (T1B*Post)	-0.005	-0.009	-0.005	-0.006
	(0.007)	(0.006)	(0.007)	(0.006)
Call Gov Privately (T1C*Post)	-0.004	-0.007	0.001	0.000
	(0.006)	(0.005)	(0.007)	(0.006)
Call Firm Privately (T1D*Post)	-0.006	-0.006	-0.001	-0.000
	(0.006)	(0.005)	(0.006)	(0.006)
Call Gov*Call Firm (T1C*TID*Post)	0.009	0.007	0.002	0.001
	(0.007)	(0.007)	(0.009)	(0.009)
Appeal Publicly on Weibo (T2A*Post)	-0.005	-0.011*	0.002	-0.001
	(0.006)	(0.006)	(0.006)	(0.006)
H0: T1A=T1B=T1C=T1D	P=0.35	P=0.11	P=0.50	P=0.40
Control Mean	0.092	0.092	0.093	0.093
Control SD	0.289	0.289	0.291	0.291
Firm FE	Yes	Yes	Yes	Yes
Day FE	Yes		Yes	
Province by Day FE		Yes		Yes
Observations	3,365,347	3,365,347	3,365,347	3,365,347

Note: This table reports the regression results from estimating Equation (1) using pipe-day level data. Abnormal Hour is a dummy variable that equals 1 if the firm's hourly records are fewer than 20 on that day, and zero otherwise. Abnormal Concentration is a dummy variable that equals 1 if the firm's daily average emission concentration of SO_2 (mg/m3) or COD (mg/L) is smaller than 1/10 of its annual average daily level, and zero otherwise. In Columns 1 and 3, we control for firm FE and day FE; in Columns 2 and 4, we control for firm FE and province-by-day FE. Standard errors are clustered two-way by prefecture and week. * $p < 0.10$, ** $p < 0.05$, *** $p < 0.01$

Table A8. Social Media Publicity and Other Citizen Appeals

	(1a)	(1b)
	Other Citizen Appeals	Other Citizen Appeals
Visibility Promotion (T2B)	-0.011	-0.007
	(0.017)	(0.018)
Control Mean	0.041	0.041
Control SD	0.200	0.200
Day FE	Yes	Yes
Province FE		Yes
Observations	408	403

Note: This table reports the regression results for public Weibo appeals on other citizen appeals. We use the sample of firms in the public Weibo appeal to government arm. The unit of analysis is each Weibo appeal. Other Citizen Appeals is a dummy variable that equals 1 if there were any appeals filed by other citizens after the Weibo appeal, and 0 otherwise. In column (1a), we control for month FE; in column (1b), we control for month FE and province FE. * $p < 0.10$, ** $p < 0.05$, *** $p < 0.01$

Table A9. Threats and Government Responsiveness

	(1a) Whether Respond	(1b) Whether Respond	(2a) Response Length	(2b) Response Length	(3a) Onsite Audit	(3b) Onsite Audit
Threat to Tell Upper-Level Government	0.01	0.02	-5.6	-8.4	-0.02	-0.02
	(0.03)	(0.03)	(19.3)	(19.2)	(0.02)	(0.02)
Threat to Tell Media	0.04	0.05	22.9	19.3	-0.00	-0.00
	(0.03)	(0.03)	(21.9)	(21.8)	(0.03)	(0.03)
Control Mean	0.59	0.59	161.3	161.3	0.21	0.21
Control SD	0.49	0.49	329.0	329.0	0.40	0.40
Month FE	Yes	Yes	Yes	Yes	Yes	Yes
Province FE		Yes		Yes		Yes
Observations	1,579	1,578	1,579	1,578	1,579	1,578

Note: This table reports the regression results for private appeals on local government responsiveness. We use the sample of firms in the private appeals to government arm. The unit of analysis is each private appeal. Whether respond is a dummy variable that equals 1 if the government formally replies to our private appeal, and 0 otherwise; response length is the word count of the government's reply to our appeal, which is counted as zero if there is no response; onsite audit is a dummy variable that equals 1 if the government replies to our private appeal with proof of an onsite investigation, and 0 otherwise. For each outcome, in the column "a", we control for month FE; in the columns "b", we control for month FE and province FE. * $p < 0.10$, ** $p < 0.05$, *** $p < 0.01$

Table A10. Effects of Multiple Private Appeals

	(1) SO2 Concentration Diff	(2) SO2 Violation Diff	(3) COD Concentration Diff	(4) COD Violation Diff
Multiple Appeals	4.837	-0.001	1.082	-0.002
	(3.902)	(0.006)	(1.600)	(0.007)
Baseline Concentration	-0.027***	-0.000	-0.082***	-0.000
	(0.003)	(0.000)	(0.008)	(0.000)
Control Mean	-1.424	-0.005	-1.312	-0.022
Control SD	62.80	0.093	27.80	0.110
Day FE	Yes	Yes	Yes	Yes
Province FE	Yes	Yes	Yes	Yes
Observations	1,731	1,731	2,187	2,187

Note: This table reports the effects of multiple private appeals using real-world appeal information. In Columns (1), the outcome variable is the change in emission concentration of SO2 (mg/m3); in Column (2), the outcome variable is the change in violation probability of SO2; in Column (3), the outcome variable is the change in emission concentration of COD (mg/L); in Column (4), the outcome variable is the change in violation probability of COD. Multiple Appeals equals 1 if there are more than one citizen filing the appeal, and 0 otherwise. We control for day FE and province FE. * $p < 0.10$, ** $p < 0.05$, *** $p < 0.01$

Appendix B. Sample Templates for Each Arm[29]

T1A: sending direct message to regulator on social media

Hello, I found that the daily average concentration of chemical oxygen demand of Xinxing Paper Co., Ltd. from Youxi County exceeded the standard value on December 25. Please refer to the attached screenshot and check the issue, thank you.

您好，我观察到尤溪县鑫兴纸业有限公司 12 月 25 日化学需氧量日均浓度超越标准值。详情见截图，请您关注并核查，谢谢。

T1B: appealing to the regulator on government website

The Fujian online monitoring platform shows that on September 15, the daily average concentration of ammonia nitrogen in the total sewage discharge outlet and the wastewater discharge outlet of Quanzhou Kaiying Power Supply Appliance Co., Ltd. exceeded the emission standard. Please refer to the attached screenshot. Please check and reply.

福建省在线监测平台显示 9 月 15 日泉州市凯鹰电源电器有限公司的污水总排放口、生产废水排放口氨氮日均浓度超标。详情见附件。请核查并说明原因。

***T1C:* appealing to the regulator by calling government hotline**

Hello, the Jiangsu Enterprise Automatic Monitoring Information Platform showed that the daily average concentration of total phosphorus in the sewage discharge outlet of Jiangyin Biyue Wastewater Treatment Co., Ltd. exceeded the standard on June 22. Please investigate and give feedback.

您好，江苏省企业自动监测信息平台显示 6 月 22 日江阴碧悦污水处理有限公司污水排放口总磷日均浓度超标。请调查并给予反馈。

T1D: appealing to the firm by phone call

Hello, I am an environmental protection enthusiast. I noticed that on May 29th, the daily average value of smoke and dust from your company's No. 1 exhaust gas discharge outlet exceeded the standard. Please pay attention to it and investigate, thank you.

您好，我是环保热心群众。我留意到 5 月 29 日贵公司的 1#废气排放口烟尘日均值超标，请您关注并进行调查，谢谢。

T2: publicly appeal to the government on Weibo

No threat

The industrial waste gas discharge outlet of Hengrun Coal Chemical Co., Ltd. located in Shenmu County exceeded the emission standard on May 29th. Please refer to the attached screenshot. Please check and provide feedback on the emission violation in time @ Yulin Ecological Environment Bureau

位于神木县的恒润煤化工有限公司的工业废气排放口 5 月 29 日烟尘日均在线数据超标，见附图，请及时核查并反馈超标原因@榆林市生态环境局

Media threat

Zhejiang Qunzhan Precision Fasteners Co., Ltd. in Jiashan County exceeded the standard value of daily average chemical oxygen demand emission at its wastewater discharge outlet on October 9. Please refer to the attached screenshot. Please check and give feedback @ Jiaxing Ecological Environment Bureau @ Jiashan Ecological Environment Bureau, if there is no response in time, I will contact the media about this matter.

嘉善县的浙江群展精密紧固件股份有限公司 10 月 9 日废水排放口化学需氧量日均值超越标准值，见附图，请核查并作出反馈@嘉兴生态环境 @嘉善环保，若未及时回复将进行媒体公开。

Upper-level government threat

The waste incinerator at discharge outlet No. 1 of Zhejiang Chunhui Environmental Energy Co., Ltd, located in the Shangyu Economic and Technological Development Zone, exceeded the daily standard value of sulfur dioxide emissions on August 16. Please refer to the attached screenshot. Please check and reply @Shaoxing Ecological Environment Bureau. If there's no reply in time, I will report this issue to the upper-level environmental protection department.

上虞经济技术开发区的浙江春晖环保能源有限公司 1#排放口 1#垃圾焚烧炉于 8 月 16 日出现二氧化硫日均值超标情况。详见附图。请核查并作出说明@绍兴生态环境， 如未回复将向上级环保部门反映。

Screenshots of Experiment Implementation Details

Sample CEMS Violation Screenshot:


江苏省重点监控企业自行监测信息发布平台

企业用户登录 环保用户登录

当前位置：首页 > 江苏华电通州热电有限公司

企业基本信息 | 自行监测方案 | 自动监测 | 手动监测 | 未监测原因 | 年度报告

☑ 废水集中排放 ☑ 废气有组织排放 查询

序号	监测点位	监测项目	监测方式	监测频次	标准值下限	标准值上限
1	废水监测点	PH值	自动监测	连续/日/次	6	9
2		化学需氧量	自动监测	连续/日/次		500 mg/l
3	废气监测点1	烟尘	自动监测	连续/日/次		5 mg/m3
4		二氧化硫	自动监测	连续/日/次	0 mg/m3	35 mg/m3
5		氮氧化物	自动监测	连续/日/次	0 mg/m3	50 mg/m3
6	废气监测点2	烟尘	自动监测	连续/日/次	0 mg/m3	5 mg/m3
7		二氧化硫	自动监测	连续/日/次	0 mg/m3	35 mg/m3
8		氮氧化物	自动监测	连续/日/次	0 mg/m3	50 mg/m3

监测点位：废气监测点1 监测项目：氮氧化物 监测时间：2019-12-04 至 2019-12-04 查询 列表 图表

序号	监测点位	监测时间	监测项目	监测值	标准值下限	标准值上限	数据状态	超标倍数	备注说明
13	废气监测点1	2019-12-04 11	氮氧化物	8.70 mg/m3 折 8.70 mg/m3	0 mg/m3	50 mg/m3	正常		
14	废气监测点1	2019-12-04 10	氮氧化物	8.69 mg/m3 折 2600.20 m...	0 mg/m3	50 mg/m3	超标	51.00	
15	废气监测点1	2019-12-04 09	氮氧化物	8.74 mg/m3 折 871.79 mg...	0 mg/m3	50 mg/m3	超标	16.44	
16	废气监测点1	2019-12-04 08	氮氧化物	8.80 mg/m3 折 600.02 mg...	0 mg/m3	50 mg/m3	超标	11.00	
17	废气监测点1	2019-12-04 07	氮氧化物	8.82 mg/m3 折 503.09 mg...	0 mg/m3	50 mg/m3	超标	9.06	
18	废气监测点1	2019-12-04 06	氮氧化物	8.80 mg/m3 折 494.29 mg...	0 mg/m3	50 mg/m3	超标	8.89	
19	废气监测点1	2019-12-04 05	氮氧化物	8.82 mg/m3 折 487.29 mg...	0 mg/m3	50 mg/m3	超标	8.75	
20	废气监测点1	2019-12-04 04	氮氧化物	8.78 mg/m3 折 539.64 mg...	0 mg/m3	50 mg/m3	超标	9.79	

20 / 1 / 2 每页 20 条,共 24

目前本站系统仅支持IE6以上浏览器（建议使用IE7或IE9），为您带来的不便我们深感抱歉

技术支持：江苏省生态环境监控中心 联系地址：南京市江东北路176号 邮编：210036 电子邮件：xxzx@jshb.gov.cn

Screenshot for T1:

T1A: sending direct message to regulator on social media

- Find the official Weibo account of the city/county's environmental bureau

- We send pollution violation information to the government through the private messages
- Testing the information barrier hypothesis

T1B: appealing to regulator on government website

On the 12369 websites, we describe the appeals and upload the screenshot.

After submitting an appeal, we will get a search code, and then we can use it to check the responses.

T1C/T1D: appealing to regulator and/or firm by phone call

Screenshot for T2:

T2: public appeal to government on Weibo

- On Weibo, we publish the company's violation information and relevant screenshots
- Use the @ function of Weibo to remind the official accounts of relevant local environmental protection bureaus to pay attention to this complaint and respond

Appendix C. Ethical Considerations

Overview

This field experiment involved working with a team of graduate students in environmental science to verify the compliance of firms with environmental standards using publicly available data from the Continuous Emissions Monitoring System (CEMS) set up under the "Measures for the Self-Monitoring and Information Disclosure of National Key Monitoring Enterprises (Trial)". We identified violations on a daily basis and, upon observing violations, we generated private or public appeals to be filed with local governments or firms by a group of citizen environmental volunteers that we recruited from one of China's local environmental protection NGOs. We use responses to the appeals and publicly available data on violations and emissions to measure the impacts of appeals.

The central government has explicitly encouraged the public to appeal violations and has mandated that local governments create specific channels for public participation, which we use to file appeals. Our field experiment is thus layered on top of existing firm-level disclosure mandates and utilizes existing channels sanctioned for public participation in the supervision of environmental regulations. Prior to launching the field experiment, we considered the impacts the treatments may have on several classes of humans and institutions.

Human Subjects

We did not collect data from or about any individual person as part of this study. All the appeals in the experiment were disseminated to institutional accounts of local governments and firms. All data used for analysis are publicly available (or a direct response to an appeal submitted as part of the experiment) and do not identify any individual government official or firm employee. Prior to launching the experiment, we sought clarification on the status of the research from the Institutional Review Boards at the University of Chicago and the University of California, Santa Barbara. Because we did not collect data about or from individual human beings, both boards determined that this project is not considered research with human subjects (UChicago protocols IRB19-1744, and letter of determination dated October 18, 2019 from UCSB FWA#00006361).

Citizen Volunteers

We partnered with several environmental protection NGOs in China to recruit a group of citizen environmental volunteers, who made public and private appeals when violations were identified using the Continuous Emissions Monitoring System (CEMS). We carefully considered the potential impacts of this research on the safety and employability of the citizen volunteers. We reviewed policy documents relevant to public participation in environmental governance in China and determined that the kinds of activities that research staff undertook for the experiment are both permitted and encouraged under current legal standards (for details, please refer to China's new environmental law and the "Interim Measures for Public Participation in Environmental Impact Assessment" and the "Provisional Measures for Encouraging Environmental Violation Appeals"). We consulted with several non-government organization that had been making similar appeals for several years and did not learn of any negative repercussions for their organizations or individual staff. During the experiment and afterwards, we were in daily contact with the citizen volunteers who made appeals and actively monitored for adverse events. We received no indications that governments or firms attempted to sanction the citizen volunteers in any way for filing appeals, likely because all appeals in this experiment used channels explicitly permitted and encouraged under central policies.

Impacts on Local Governments

This field experiment increased the number of appeals about violations of pollution standards that were filed with local governments. It is likely that responding to these appeals involved time and effort. It is important to note that local governments are explicitly mandated to respond to appeals from the public and actively monitor reports of non-compliance through various channels for public participation ("Provisional Measures for Encouraging Environmental Violation Appeals"). Thus, while our experiment may have increased the effort required by local governments to regulate pollution, that effort is consistent with existing mandates and responsibilities under the law.

We considered the possibility that appeals from a research project could make local governments less responsive to public appeals in the future. We believe this is unlikely given the size of our experiment relative to existing public participation in environmental supervision. During the experiment, we identified a total of 5366 violations across all the experimental arms. Data from channels for public participation such as the 12369 hotline and website indicate that more than 600,000 appeals about pollution are filed by the public annually. Accordingly, we do not believe that the intensity of the treatments will influence government responsiveness to the public in the future. We also consulted with local organizations like the Institute of Public and Environmental Affairs (IPE) and the Public Environment Concerned Center (PECC) to ensure that the appeals filed during the experiment were consistent in channel and content with other public appeals.

Impacts on Firms

The firms that were subject to appeals in this field experiment may have had to increase their effort to comply with environmental standards, which likely imposed costs. We note that appeals were only triggered for firms that exceeded existing pollution standards set by Ministry of Ecology and Environment. Since the current environmental law has made it clear that these violations should be eliminated to promote environmental quality and public health, we considered it acceptable to impose costs of firms through the treatment, since policymakers have judged those costs to be acceptable considering the potential public benefits of reductions in pollution.