Environmental Citizen Complaints[*]

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Abstract

Citizen complaints feature prominently in public oversight contexts. The nature and effects of complaints, however, are controversial and poorly understood. We first investigate attitudes about citizen complaints using a nationally representative survey. We document that the public believes complaints promote open, efficient, and equitable governance. We then exploit novel administrative data on over 130,000 complaints in Texas to investigate their observed dynamic effects on regulator behavior. Empirically, complaints are associated with sharp increases in regulator monitoring and enforcement. Complaints uncover more, and more severe violations, than more standard monitoring approaches. Overall, our findings are consistent with complaints enhancing regulatory efficiency.

1   Introduction

Citizen complaints, where community members file concerns directly with a regulator, feature prominently in public oversight contexts ranging from policing and corruption (Harris et al., 2017; Owens and Ba, 2021; Botero et al., 2013) to environmental protection and occupational safety (Weil and Pyles, 2005; U.S. Environmental Protection Agency, 2021). Conventional wisdom suggests that citizen complaints are popular with the public. Proponents of complaints argue that they enhance procedural justice and allow individuals to participate directly in decisions that influence their welfare and communities. Citizen complaints may offer low-cost sources of information and bring attention to problems undetected by more costly regulatory monitoring. However, complaints may not always be reliable and may reallocate regulatory attention away from problems generating greater harm. Economists and policymakers debate the extent to which complaints lead to misallocation of limited regulatory resources (Bradstreet, 1993; Dasgupta and Wheeler, 1997; Martinez and Pskowski, 2023).

Despite theoretical ambiguity and policy prominence, the nature and effects of real world citizen complaints remain poorly understood. In this paper, we provide new evidence on citizen complaints related to environmental concerns. We first present evidence on attitudes and beliefs using data from a nationally representative survey of U.S. residents. We then use administrative data on environmental citizen complaints in Texas to explore the dynamic effects of citizen complaints on regulator behavior. Finally, we use our results to consider overall efficiency and distributional implications of citizen complaints.

Our national survey evidence reveals that, on average, the general public believes that citizen reports of pollution concerns improve public transparency and accountability, provide high quality local information, and promote environmental justice. On average, the general public does not believe that regulatory responses to citizen complaints waste public enforcement resources or allow environmental activists and NGOs to have undue influence on environmental agencies. This is the first nationally representative evidence on beliefs about citizen complaints in the United States, contributing to a literature using surveys to better understand public thought about economic and policy topics (Stantcheva, 2020, Forthcoming; Muehlenbachs and Campa, Forthcoming). While these survey results provide new insights into perceptions about promoting open and equitable governance – critical components of distributive and procedural justice – understanding the efficiency and distributional consequences of complaints requires an analysis of how regulators respond to complaints and what they find when they do respond.

To explore the effects of citizen complaints on regulator behavior, we combine daily,

facility-level, data on the universe of citizen complaints made to the Texas Commission on Environmental Quality (TCEQ) between 2003 and 2019 with regulator investigations, notices of violations, and notices of enforcement. Our sample includes more than 23,000 facilities regulated under two major Clean Air Act programs. Texas is the U.S. state with the largest number of significant air pollution emitters. According to EPA data, it contains approximately 20 percent of the country's facilities formally classified as "major emitters" under the Clean Air Act.

We evaluate the dynamic effects of citizen complaints on regulatory behavior. If we focused on the contemporaneous relationship alone, we could miss potential margins of response. However, identifying dynamic effects is empirically challenging when events are transitory, staggered, and when facilities are exposed to repeat events. To investigate the dynamics of regulatory responses, we use a panel-data local projections estimator (Jorda, 2005, 2023) and estimate the impulse response function following a complaint. Under reasonable conditions, the local projections estimator is the most consistent for identifying the dynamic effects of repeat transitory shocks like citizen complaints (Bojinov et al., 2021; Rambachan and Shephard, 2021; Basso et al., 2022). Our approach assumes conditional independence – that there is no residual month-to-month variation within a facility-year that is correlated with both the likelihood of receiving a complaint and the likelihood of regulatory attention for reasons unrelated to the complaint. Our results are robust to falsification tests, controlling for pollution events observable to the regulator, and a broad range of checks designed to address natural omitted variable concerns.

First, we show that citizen complaints are associated with a marked regulatory response. Despite regulatory discretion, on average complaints against a facility are associated with a very large and immediate increase in the likelihood of an on-site complaint investigation as well as an increased likelihood of a non-complaint investigation (i.e., one not directly linked to a complaint) for up to six months thereafter. Complaint investigations also uncover substantial noncompliance. Complaints against a facility are associated with significant increases in the likelihood of formal notices of violation and enforcement up to four months thereafter.

Second, we inform the overall regulatory implications. We document that investigations associated with complaints are two to four times more likely to uncover violations than investigations not triggered by complaints. Violations detected during investigations triggered by complaints are more severe on average. Complaint investigations are significantly more likely to lead to formal enforcement actions than standard monitoring activities. We find no evidence that complaint investigations spillover to crowd out investigations and enforcement at other sample facilities on the margin (Evans et al., 2018; Maniloff and Kaffine, 2021). We

find no evidence of a differential regulatory response to complaints along margins of race, income, or urbanicity.

Taken as a whole, our findings are consistent with citizen complaints serving as an effective targeting mechanism and enhancing regulatory efficiency in a distributionally neutral fashion. A back-of-the-envelope calculation based on our results shows that TCEQ's monitoring budget for sample facilities would increase between 3 and 14 percent if the agency replaced investigations of complaints with routine monitoring activities while holding constant the level of expected benefits.

We contribute to a growing literature on citizen engagement. We focus on the form of citizen engagement where community members independently file complaints about local entities directly with the regulator. The relevance and accuracy of complaint information is *ex ante* unknown to the regulator. We contrast this context with a literature that studies a form of citizen engagement that emphasizes "naming and shaming" to enhance a community's Coasian bargaining position or otherwise leverage external pressures (Bae et al., 2010; Johnson, 2020; Buntaine et al., Forthcoming). In this literature, the primary treatment is curated information disclosure to the public and disclosed information has already been fully collected and validated by government agencies.

Our analysis provides early comprehensive evidence on the effects of complaints of unknown novelty and validity filed directly with a regulator in the United States. This setting contrasts with the small existing literature, which focuses on developing and transitional economies where complaints may serve largely as a substitute for costly agency monitoring (Pargal and Wheeler, 1996; Afsah et al., 1996; Dasgupta and Wheeler, 1997; Dong, 2011). In developing country contexts, complaints are presumed impactful as other forms of regulation may be "weak or absent" (Pargal and Wheeler, 1996) and regulator monitoring resources may be "scarce or nonexistent" (Dasgupta and Wheeler, 1997). By contrast, we study the U.S. regulatory system – a mature monitoring and enforcement regime where complaints serve solely as inputs into established formal regulatory processes. In this context, there is a paucity of systematic empirical evidence. Our rich administrative data allow us to characterize the dynamic effects and implications of complaints across all sectors operating under entire Clean Air Act programs. This contrasts with the handful of other studies in this context, which explore the correlates and implications of a few hundred to a few thousand complaints in a single industry like oil and gas wells or livestock operations due to data constraints (Huang and Miller, 2006; Maniloff and Kaffine, 2021; Scott, 2018; Di Salvo et al., 2022).[1]

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[1]A small related literature explores citizen litigation or non-profit monitoring rather than citizen complaints (Earnhart, 2000; Langpap and Shimshack, 2010; Ashenmiller and Norman, 2011; Grant and Grooms,

We also contribute to a broader literature on the determinants of regulator behavior (Hilton, 1972; Joskow, 1974; Leaver, 2009). A key contribution of the existing literature here is an emphasis on regulatory discretion in pollution oversight. In addition to showing that monitoring and enforcement are responsive to harm, local environmental quality, and compliance costs (Kleit et al., 1998; Stafford, 2002; Gray and Shadbegian, 2004; Blundell et al., 2020; Kang and Silveira, 2021), as expected, the literature also documents that regulators are highly responsive to political and economic considerations including agency budgets, strategic bureaucratic interests, corruption, compliance history, and local community characteristics correlated with political activism (Niskansen, 1972; Helland, 1998; Earnhart, 2004; Innes and Mitra, 2015; Grainger et al., 2019; Blundell et al., 2021; Zou, 2021; Mu et al., 2022; Shimshack and Ward, 2022; Morehouse and Rubin, 2023). Our primary contribution to this literature is to show that citizen complaints play an important role in pollution oversight and enhance regulatory efficiency in a distributionally neutral way.

2 Background and Concepts

Environmental agencies solicit complaints when citizens have information about an environmental issue. Examples of complaints include unpleasant sights and smells and potential violations of environmental regulations. Typically, citizens may submit complaints online or by phone 24 hours per day, 7 days per week.[2] Complainants are usually able to track the environmental agency's response to the complaint.

Conventional wisdom and the related literature identify several potential advantages of environmental citizen complaints. First, citizen complaints may promote perceptions of open government, transparency, and public accountability (Botero et al., 2013). Second, citizen complaints may enhance regulatory efficiency. One argument in support of state, local, and tribal administration of federal environmental programs relies on the superior information available to local agents compared to environmental agency officials. Citizen complaints may enhance the information quality if they draw attention to pollution concerns not detected by costly agency monitoring (Oates, 1972; Millimet, 2013). Third, citizen complaints may promote distributional equity and procedural justice. Citizen complaints allow individuals to provide input into regulatory decisions that influence household and community level well-being. This sentiment is echoed in the US Environmental Protection's core mission, part of which promotes "meaningful involvement of all people ... with respect to the ... implementation and enforcement of environmental laws, regulations, and policies... regardless

2017; Grant and Langpap, 2019).

[2]Complaints are also commonly accepted by walk-in, letter, fax, and email.

of race, income, and other demographics" (U.S. Environmental Protection Agency, 2021). Some local environmental advocacy agencies (e.g., Air Alliance Houston) encourage citizen participation via complaints by highlighting information on how to submit environmental complaints to regulators on their websites.

The existing literature also highlights several potential concerns about environmental citizen complaints. First, citizen complaints may fail to provide new or reliable information, which may result in wasted or duplicative agency efforts that reduce regulatory efficiency. Second, even if the information provided is new and reliable, citizen complaints need not identify environmental problems with the most significant harm. If citizen complaints divert scarce regulatory resources away from problems generating greater harm, then they may reduce regulatory efficiency (Dasgupta and Wheeler, 1997). Third, the presumption that citizen complaints enhance procedural and environmental justice relies on assumptions of equal regulatory responses to complaints across space. The literature suggests that regulatory enforcement may be lower in disadvantaged communities (Konisky, 2009; Shadbegian and Gray, 2012), so responses to complaints may be similarly associated with community characteristics (Dasgupta and Wheeler, 1997).

2.1   Public Attitudes

One natural starting point to explore the empirical relevance of the potential advantages and disadvantages of environmental citizen complaints is to simply ask the general public about their attitudes towards complaints. To our knowledge, the extant literature has not taken this first step. As such, we explore common citizen complaint conjectures with results from a national survey. We contracted with third-party vendor Qualtrics to obtain responses from a nationally representative sample of approximately 2,500 U.S. adults aged 18 or older. The survey remained open between May 26, 2022 and June 7, 2022. We received completed responses from 2,513 adults located in all 50 states. National representation was determined on the basis of gender, age, race, and income. Roughly paralleling the U.S. adult population, among respondents in the final sample, 53 percent were female, 12 percent identified as non-Hispanic Black, 69 percent identified as non-Hispanic white, and 74 percent reported having at least some college experience. 42 percent of respondents most identified with the Democrat political party. The average age among (adult) respondents to the survey was 45 (Table B1).[3]

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[3]The survey partner, Qualtrics, managed all survey respondent recruitment and compensation. Qualtrics participants are not professional survey takers. Qualtrics pretests all surveys and manages response quality throughout the process, including scrubbing data to flag respondents that speed through surveys, straightline respond, or respond in gibberish. See Appendix B for more details on survey design and implementation. Since we do not observe non-respondents, we acknowledge that we cannot fully rule out experimenter demand effects or other survey bias issues.

After providing context about state environmental agencies (EAs), our survey asked respondents the degree to which they agreed that citizen reports of pollution concerns: (1) Provide better information on local pollution problems than the EA gets during its inspections; (2) Promote environmental justice and the protection of vulnerable populations in the community; (3) Involve false or bad information that wastes the EA's resources; (4) Promote basic rights, open government, transparency, and accountability; and (5) Allow environmental activists and environmental organizations to have too much influence on the EA.

Key results are summarized in Figure 1.[4] On average, survey respondents agreed with commonly asserted advantages of environmental citizen complaints (Figures 1a, 1b, 1c). 58 percent of respondents agreed or strongly agreed that citizen reports provide better information on local pollution problems than the EA gets through its own inspections; 10 percent disagreed or strongly disagreed. 66 percent of respondents agreed or strongly agreed that citizen complaints support environmental justice and the protection of vulnerable populations; 8 percent disagreed or strongly disagreed. 67 percent of respondents agreed or strongly agreed that citizen reports promote open government, transparency, and public accountability; 7 percent disagreed or strongly disagreed. On average, older, non-Hispanic white, more educated, and Democrat respondents were significantly more inclined towards agreeing with commonly asserted advantages of citizen complaints (Figures B1a, B1b, B1c).

In contrast, on average, survey respondents neither clearly agreed nor clearly disagreed with commonly asserted disadvantages of environmental citizen complaints (Figures 1d, 1e). 39 percent of respondents neither agreed nor disagreed that citizen reports involve false or bad information that wastes the EA's resources; 28 percent agreed or strongly agreed and 33 percent disagreed or strongly disagreed. 36 percent of respondents neither agreed nor disagreed that citizen complaints allow environmental activists and non-governmental organizations to have too much influence on EA activities; 35 percent agreed or strongly agreed and 29 percent disagreed or strongly disagreed. Male, Republican, more educated, and younger respondents were significantly more likely to perceive that citizen reports of pollution concerns wasted resources or allowed environmental activists and NGOs to have too much influence on the EA (Figures B1d, B1e).

2.2 Open Empirical Questions

Regarding the literature's conjecture that environmental citizen complaints enhance perceptions of open government and public accountability, attitudinal results from our national

[4]Survey results from respondents residing in Texas – the focus of our later empirical work – are qualitatively similar, although noisier given the reduced sample size of 173 respondents (Appendix B.2).

survey may be sufficient. However, informing questions about the extent to which environmental citizen complaints promote regulatory efficiency and environmental justice requires empirical evidence on regulatory responses to complaints.

A first-order empirical question is: (1) To what extent do environmental regulators actually respond to citizen complaints? Despite guidelines suggesting that EAs should investigate complaints according to established criteria, it is not clear *ex-ante* how much EAs respond to complaints of uncertain validity and severity in practice. EA budgets are highly constrained and regulatory activities like investigations involve substantial costs. As discussed in more detail in Section 4, regulatory discretion is pronounced throughout environmental policy, including with regard to the frequency and intensity of investigative efforts (Shimshack, 2014; Shimshack and Ward, 2022).

Additional questions relevant for efficiency and environmental justice considerations include: (2) To what extent do regulatory investigations associated with citizen complaints uncover significant harm? If citizen complaints predominantly uncover nuisance issues or less severe violations, citizen complaints may represent inefficient regulatory targeting mechanisms. (3) On the margin, to what extent do investigations triggered by citizen complaints crowd out regulatory activity at regulated entities not subject to complaints? (4) Do regulators respond differently to environmental citizen complaints in areas with different socioeconomic characteristics?

3 Complaints Data and Descriptive Facts

To explore unanswered empirical questions, we obtained administrative data via a public information request (PIR 21-65675) on the universe of pollution concerns reported to the Texas Commission on Environmental Quality between January 1, 2003 to December 31, 2019. Texas is the second largest U.S. state by population and land area and contains a disproportionate share of major emitters under the Clean Air Act. We focus on the 2003-2019 sample period for reasons of data reliability. Data are incomplete prior to 2003 and 2019 was the last full year of data available at the time of our last information request.

The Texas Commission on Environmental Quality (TCEQ), Texas's state environmental agency, tracks all citizen complaints received.[5] However, not all complaints received are

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[5]Figure C1 shows the range of options available to citizens from the the TCEQ website (https://www.tceq.texas.gov/compliance/complaints/). Individuals may make complaints at any time using the website complaint form (Figure C2), calling a toll-free number, contacting their local regional office, or emailing complaint@tceq.texas.gov. Complaints are also accepted by walk-in, letter, and fax. Complainants are informed by TCEQ that they may provide their contact information including name, email, address, and phone number. Complainants, even if they choose to remain anonymous, are provided with an incident number that may be used to track TCEQ's response to the complaint. Complainants are advised that

TCEQ's responsibility. TCEQ does not have direct regulatory authority over septic systems, trash dumping, and noise pollution.[6] These complaints fall under the purview of the city or county, the local police or fire department, or other authorities. Regulation of activities at oil and gas facilities may fall to the Railroad Commission of Texas or TCEQ, depending on the nature of the activity. In general, activities at oil and gas facilities that affect air quality, water quality, and waste management fall under TCEQ's jurisdiction.[7] Finally, some urban localities maintain primacy for local air pollution control. These include Dallas, Fort Worth, El Paso, and Houston, as well as Galveston County and Harris County.

For each complaint received, TCEQ creates an administrative record including an incident number and receipt date. We adopt the term "complaint" to reference what TCEQ refers to as a "complaint incident". In practice, a complaint incident may involve multiple reports. In this case, TCEQ does not maintain separate identifiers for the multiple reports; all reports are assigned to the relevant complaint incident. 98% of complaint incidents have only one report (Figure C3). The 99th percentile is 2 reports and the maximum number of reports is 129. Although the largest outliers may represent letter writing campaigns, evidence consistent with such campaigns or other forms of potentially excessive complaints is scant in our data.

Administrative complaint records include complainant-provided incident date, approximate incident time, location or address where the problem is occurring, nearest city or town and county, source(s) of the problem if known, and a brief text summary of the concern. Agency personnel evaluate the complaint text to identify and code key features of the complaint, such as causes, key concerns, and relevant environmental medium or media. For all complaints under its jurisdiction, TCEQ also assigns a regulated entity number, which identifies the respondent (i.e., the entity about which the complaint refers) when known to TCEQ or a generic placeholder when not known. Using the location of the complaint respondent, we combine the complaints data with demographic data at the zip-code level from the 2000 Decennial Census as well as average annual estimates of PM2.5 at the zip-code level using data from Meng et al. (2019) and following methods in Colmer et al. (2020).

During our 17-year sample period, 2003 through 2019, TCEQ documented 130,178 unique

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some key regulations prohibit TCEQ follow-up of anonymous complaints. For example, regulations may prevent TCEQ from documenting a nuisance odor violation for anonymously submitted complaints. Generally speaking, the processes documented here are consistent with citizen complaint programs managed by other state environmental agencies. For example, see Maryland (https://mde.maryland.gov/Pages/Open-MDE.aspx), New Jersey (https://www.nj.gov/dep/enforcement/sub_5_guidlines_39njr912.pdf), and Iowa (https://www.legis.iowa.gov/docs/iac/chapter/10-05-2022.561.3.pdf).

[6]Our focus is on traditional pollution complaints. A significant fraction of complaints in the related literature address noise complaints from trucking around oil and gas installations (Maniloff and Kaffine, 2021; Di Salvo et al., 2022).

[7]For more details, see 16 Tex. Admin. Code §3.30, which specifies a memorandum of understanding between TCEQ and the Railroad Commission.

formal complaint incidents.[8] Figure 2 depicts temporal variation. The annual number of complaints received by TCEQ was ∼ 7,000 between 2003 to 2011, dropped to ∼6,000 in 2012 and 2013, and then trended steadily upward to a peak of 9,862 in 2018 (Figure 2a). Complaints spiked following Hurricane Harvey (12 August 2017) and increased after a major flooding event (17 October 2018). Complaints are mildly seasonal, with fewer complaints in November, December, and the other winter months (Figure 2b). Complaints are less common on Fridays than other weekdays and are rare on weekend days (Figure 2c).[9]

We summarize pollution medium and the spatial distribution of complaints per capita focusing on the 110,745 complaints between 2003 and 2019 that fall under TCEQ's jurisdiction.[10] Complaints per capita do not systematically cluster in major urban areas (Figure C4).[11] Complaints per capita appear higher west of Abilene, northeast of Amarillo, and around Waco.[12]

Among complaints for which we observe environmental media, roughly 39 percent are associated with air, 38 percent are associated with water, 21 percent are associated with waste, and 2 percent are associated with multiple media (Figure C5). Among air complaints, more than half address odor, and about 20 percent address dust, 10 percent address smoke, and 10 percent address outdoor burning (Figure C6). Among water complaints, roughly 17 percent address wastewater, 17 percent address water supply quality, 14 percent address stormwater, and 10 percent address water supply service. Among waste complaints, more than 30 percent address municipal waste, more than 20 percent address odor, 10 percent address industrial waste, and approximately 8 percent address petroleum storage tanks. [13] Trends in incident nature and incident concerns are presented in Figures C7 and C8. Appendix C reports additional descriptive results including a more detailed exploration of the content of environmental citizen complaints using text analysis tools.

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[8]This count excludes around 4,500 incidents for which the complaint received date is listed as January 1, 1800. 90 percent of these appear to have been submitted prior to 2003 based on other available information in the data.

[9]Subsequent empirical analysis is conducted at the monthly level (with sensitivity analysis at weekly level), so short lags between complainant reporting and TCEQ administrative record-keeping are unlikely to influence results.

[10]Overall TCEQ referred about 15 percent of complaints to other agencies during this period. The referral rate was about 6 percent, 24 percent, and 17 percent for air, waste, and water complaints, respectively.

[11]All results in this section are robust to dropping major cities where TCEQ may cede primary regulatory oversight to another agency.

[12]See Figure C9 for cross-sectional socioeconomic correlates of per capita complaint incidents at the zip-code level.

[13]Eight percent of air complaints, 6 percent of water complaints, and 3 percent of waste complaints report concerns formally coded as health-related. 7 percent of air complaints, 5 percent of water complaints, and 5 percent of waste complaints report concerns formally coded as related to property.

4   Identifying Regulator Responses to Complaints

As noted above, understanding the implications of citizen-reported pollution concerns for environmental policy requires an understanding of how complaints affect regulator behavior. In this section, we explore the dynamic relationship between citizen complaints and regulator monitoring and enforcement activities. To do so, we must define a set of regulated facilities over which TCEQ has clear and coherent regulatory authority. That is, we must identify a set of facilities that consistently show up on TCEQ's "regulatory radar" whether or not the facilities are the subjects of citizen complaints. We construct an estimation sample that includes facilities with permits under the two most significant and standardized Clean Air Act (CAA) regulatory programs overseen by TCEQ: the Title V and New Source Review (NSR) programs. Given our focus on CAA-regulated facilities, we henceforth restrict attention to air complaints.

4.1   Title V and New Source Review Programs in Texas

Permitting, monitoring, complaint protocols, and enforcement for stationary sources of air pollution in Texas are governed by a complex set of regulations and procedures. Broad legislation includes the Clean Air Act (CAA) and Texas Administrative Code Title 30. Title V operating permits govern normal operations at (mostly) large industrial establishments. NSR permits govern administrative and technical matters before and after a facility undergoes construction or modification that could potentially affect air quality. Title V and NSR permits govern performance and investigation tracking and may stipulate requirements about emissions reporting, emissions limits, and operating conditions.

Although federal laws establish the general framework, TCEQ, predecessor agencies, and local partner agencies retain primary permitting, monitoring, and enforcement responsibilities (i.e., primacy) for major air pollution programs. TCEQ monitoring activities, which take several forms, are organized by TCEQ region with investigators typically assigned to monitor facilities located within the same TCEQ region.[14] Texas is divided into 16 TCEQ regions, making the average region slightly larger than Maryland. Primary monitoring activities include compliance investigations, site assessments, compliance investigation file reviews, and site assessment file reviews.[15] The former two activities take place on-site at the regulated

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[14]If an investigator from within the TCEQ region is unavailable, then an investigator from another TCEQ region may be assigned. Information on TCEQ regions is available at https://www.tceq.texas.gov/agency/directory/region.

[15]Other forms of pollution monitoring may include continuous emissions monitoring systems that provide compliance determinations for some pollutants in real time, facility self-reporting, and facility self-certification.

facility and the latter two activities occur off-site. TCEQ distinguishes between monitoring activities that follow up on citizen complaints (i.e., which we call "complaint investigations") and those that happen for other reasons (i.e., which we call "non-complaint investigations"). Non-complaint investigations fulfill routine compliance monitoring requirements or arise for other reasons unrelated to a citizen complaint and may be on-site or off-site.

TCEQ provides guidelines on compliance monitoring following receipt of a citizen complaint. Under the guidelines, once a complaint is determined to fall under the agency's regulatory authority, the complaint is assigned to a field investigator. The field investigator is expected to engage with monitoring activities in the same way as they would for a routine investigation with two exceptions. Complaint investigations are almost always on-site. For on-site complaint investigations, TCEQ guidance recommends no or minimal advance notice to facilities (TCEQ, 2021).

Although citizen complaints can, in principle, provide emissions or compliance monitoring data, it is extremely rare for citizen complaints to directly serve as foundations for violation determinations and enforcement. Direct complaint case support requires a notarized affidavit, the complainant's willingness to testify in formal enforcement proceedings, and (in many cases) documentation gathered and prepared using agency procedures requiring specialized training. As such, citizen complaints serve to trigger agency investigations, which may uncover and document violations.

Whether triggered by complaints or more standard monitoring activities, investigators detecting noncompliance formally document issues with a notice of violation (NOV). NOVs specify the nature and severity of noncompliance and a response timeline. Violations not quickly resolved, and severe or chronic violations, may result in a notice of enforcement (NOE), which informs a facility that TCEQ is initiating formal enforcement action.

TCEQ's Enforcement Initiation Criteria suggest an appropriate response for different categories of violations, whether detected by routine monitoring or complaint investigations (TCEQ, 2020). Enforcement options include administrative orders with and without fines, referrals to attorneys general for civil judicial cases, or criminal judicial proceedings. Enforcement guidelines suggest penalty type and severity should be a function of the extent of violation, actual/potential harm, intent, economic benefit, and other factors. The overwhelming majority of violations are addressed with informal actions like warning letters, or with formal actions like administrative orders. Civil cases are uncommon. Criminal cases are extremely rare and tend to be reserved for intentional violations with extreme harm or intentionally false statements (Uhlmann, 2009).

4.2 Regulatory Discretion

Despite guidelines, in Texas and elsewhere, regulatory discretion is pronounced. Legal requirements, violations, monitoring activities, and enforcement actions are technically and administratively complex. Monitoring and enforcement are costly, and political and economic factors within environmental agencies and between regulators and firms may affect implementation (Gray and Deily, 1996; Shimshack, 2014; Shimshack and Ward, 2022).

As a consequence, nearly all aspects of environmental monitoring and enforcement are uncertain *ex-ante*. In practice, inspection frequency and intensity for similar facilities varies significantly across states and through time (U.S. Environmental Protection Agency Office of Inspector General, 2020). Despite enforcement guidelines to the contrary, many environmental violations simply go unsanctioned (Shimshack and Ward, 2022). Average penalties for detected violations under both the Clean Air Act and the Clean Water Act can vary by orders of magnitude from state to state (Shimshack, 2014; Anderson and Vaughan, 2023). EPA's State Review Framework (SRF), which oversees state-delegated compliance and enforcement programs, routinely finds state efforts to administer federal environmental programs deficient, characterizing 57% and 54% of its state review findings under the CAA as an "Area for Attention" or "Area for Improvement", respectively.[16]

We reiterate briefly two implications of a setting characterized by significant regulatory discretion and citizen complaints of unknown accuracy. First, it is unclear *a priori* how frequently and how intensely TCEQ responds to complaints. Although guidelines suggest complaints should receive regulatory attention, if, when, and how this occurs in practice are open empirical questions. Second, it is unclear what regulators will find when they do respond to complaints. The extent to which complaints actually uncover violations, significant noncompliance, and/or lead to enforcement actions is unclear *ex-ante*.

4.3 Estimation sample

Our public information request solicited data on all unique Title V / NSR facilities permitted in Texas. Using these data, we constructed a balanced panel excluding those Title V/NSR facilities that were never investigated during our sample period as these facilities are unlikely to be under TCEQ's regulatory jurisdiction during the period of study (e.g., their permits expired prior to the start of our sample period in 2003).

Our final analysis sample represents a facility-by-month panel of 23,100 unique Title V / NSR facilities covering the 204 months from 2003 to 2019 ($n = 4,712,400$). For each of

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[16]Author calculations based on data from the SRF Results Table available at https://www.epa.gov/compliance/state-review-framework-results-table. Accessed on November 3, 2023.

our 23,100 sample facilities, we use regulated entity identifiers to merge in data on facility characteristics, air investigations, air notices of violation (NOVs), air notices of enforcement (NOEs), and other regulatory information. Using geographic identifiers, we merge in supplemental data including socio-demographic data at the zip-code level from the 2000 Decennial Census. Finally, we merge in air complaints naming that regulated entity as the subject of the complaint.[17] Figure A1 maps the geographic distribution of estimation sample facilities by zip code. Sample facilities are more concentrated in areas close to Texas's shale plays.[18]

Roughly 90 percent of facilities in our sample hold only an NSR permit, 10 percent hold both NSR and Title V permits, and half a percent hold only a Title V permit. In support of our decision to focus on Title V/NSR permit holders, over 21 percent of *all* complaints in the sample period not referred to another agency are directed towards these facilities. Restricting attention to non-referred air complaints, over one third are linked to the facilities in our sample.

17 percent of facilities in our sample were named in at least one non-referred air complaint incident between 2003 and 2019. Among these facilities, 46 percent were named in more than one non-referred air complaint incident.[19] Consistent with stylized facts from the broader enforcement and monitoring literature, regulator investigations (i.e., inspections) are infrequent and enforcement activities are rare. In an average sample month, 2.5 percent of sample facilities were inspected, 0.32 percent received an NOV, 0.05 percent received an NOE, and 0.21 percent received a non-referred complaint. Over the 204 month sample period, the average facility is investigated by TCEQ in five of those months. Complaint investigations represent a relatively small fraction, less than 10 percent, of total investigations in our sample. Table A1 provides additional summary statistics for the estimation sample.

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[17]Given our focus on Title V and NSR air polluting facilities, our regulatory analysis does not consider water or waste complaints. We do not consider non-referred air complaints naming regulated entities not governed by Title V and NSR permits. This most frequently includes air complaints naming regulated entity numbers not linked to any facility regulated by TCEQ. For example, a citizen might file a complaint against a neighbor burning tires. TCEQ would assign a regulated entity number to the neighbor, even though this individual is not otherwise regulated by TCEQ.

[18]Unfortunately we do not have information on industry for about a quarter of facilities in our sample. Among those for which we observe industry classification, about 14 percent are assigned to multiple industries. For facilities assigned to a single industrial sector, industries with significant representation include oil and gas extraction; stone, clay, glass and concrete products; non-fuel mining and quarrying; chemicals and allied products; utilities; and fabricated metal products.

[19]Two percent of sample facilities were named in five or more non-referred air complaint incidents and one percent received 10 or more non-referred air complaint incidents during the sample period. The maximum number of non-referred air complaint incidents for a single sample facility is 374.

4.4 Research Design

We identify dynamic regulatory responses to complaints. A contemporaneous analysis would only identify whether regulators respond immediately to complaints, potentially missing out on important response dimensions. This is especially important when wanting to understand the full consequences of an investigation, rather than whether an investigation simply took place.

We evaluate the dynamic relationships between citizen complaints and regulator investigations, notices of violation, and notices of enforcement. Citizen complaints represent transitory shocks, are staggered over time, and can be repeat events. As such, commonly used generalized difference-in-differences (DiD) research designs, which are more suited to evaluating policy changes characterized as absorbing states, are not appropriate.

Instead, we primarily draw on insights from the macroeconomics literature – which has given a lot of thought to estimating the dynamic effects of transitory shocks (Jorda, 2005; Ramey, 2016; Nakamura and Steinsson, 2018; Stock and Watson, 2018; Bojinov et al., 2021; Rambachan and Shephard, 2021; Jorda, 2023) – to build a comprehensive understanding of the dynamic relationships between citizen complaints and regulator behavior. Following Jorda (2005, 2023), we implement the panel-data local projections estimator.[20] The local projections estimator produces a separate estimate for each horizon of interest, imposing limited structure on the underlying data generating process.[21]

For each time-horizon h, we estimate the following specification,

$$\Delta Y_{i,t+h} = \beta^h Complaint_{i,t} + \alpha_{i,y} + \delta_t + \epsilon_{i,t} \tag{1}$$

$\Delta Y_{i,t+h}$ is the change in the likelihood of an investigation, notice of violation (NOV), or notice of enforcement (NOE), in month $t + h$ relative to the month prior to the complaint for facility i. $Complaint_{i,t}$ is an indicator variable equal to 1 if the regulator received a (non-referred) citizen complaint about facility i in month t, and 0 otherwise. We include facility-by-year fixed effects, $\alpha_{i,y}$, and month of sample fixed effects, δ_t. Standard errors are clustered at the facility-level (i.e., the unit of exposure). Our results are robust to accounting for broader spatial correlations (e.g., county).

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[20] Jorda (2023) provides an excellent overview of the local projections approach written for an applied micro audience.

[21] This contrasts with other dynamic panel-data estimators that extrapolate into increasingly distant horizons while imposing a linear global approximation of the underlying data generating process. Plagborg-Moller and Wolf (2021) show that in finite samples, the local projections estimator generates less biased estimates of the dynamic response than other commonly implemented estimators. Basso et al. (2022) show that in the case of repeat events distributed-lag models can produce biased estimates of the dynamic response compared to the local projections estimator.

4.5 Identification Assumptions

Under the assumptions of linear potential outcomes and conditional independence, β^h identifies the average effect of receiving a citizen complaint on the outcome of interest in horizon h (Bojinov et al., 2021; Rambachan and Shephard, 2021; Basso et al., 2022), relative to $t-1$. For example, the contemporaneous effect of a citizen complaint is captured by β^0 and the estimated effect of a citizen complaint after 3 months is captured by β^3.

In equation 1, conditional independence requires that there is no residual month-to-month variation within a facility-year that is correlated with both the likelihood of receiving a complaint and the likelihood of receiving regulatory attention for reasons unrelated to the complaint. It is possible that other idiosyncratic shocks at the facility level influence both the likelihood of receiving complaints and the monitoring and enforcement activities of the regulator for reasons other than complaints themselves. We engage with this potential threat to identification in several ways. First, in addition to exploring relationships between complaints and all investigations, we are able to restrict our attention to analyzing the effect of complaints on investigations that are explicitly linked to citizen complaints. Here, we identify the conditional relationship between a complaint incident and whether and when that complaint directly resulted in a follow-up investigation. Detected relationships can not be driven by an omitted variable that simultaneously influences the probability of complaints and overall regulatory scrutiny. Of course, this exercise does not fully address concerns of omitted variable bias related to empirical relationships between complaints and non-complaint investigations, NOVs, and NOEs.

Second, we conduct a falsification test. In our original dataset, we observe *all* complaints that TCEQ receives including those that do not fall under TCEQ's jurisdiction, which are referred to other agencies. These referred complaints should be subject to the same omitted variable concerns but have no direct influence on the probability of TCEQ investigation, NOVs, NOEs, or other regulatory responses. As such, an analysis using complaints received by TCEQ but referred to other jurisdictions allows us to evaluate the empirical relevance of omitted variable bias. If facilities that receive more complaints are also differentially more likely to receive regulatory attention for other time-varying reasons, for example, if TCEQ infers that facilities should receive increased regulatory scrutiny when they receive complaints that are outside of their jurisdiction, then we should estimate a significant effect of receiving a referred complaint on TCEQ regulatory responses. As noted in the next section, we do not detect any evidence that these sources of omitted variable bias are empirically relevant in this context.

Third, we directly control for several natural omitted variables with additional robustness checks. We consider sensitivity to including county-by-month fixed effects, which cap-

ture considerations like local changes in weather and resources devoted to enforcement and monitoring. We add industry-by-month fixed effects, which capture market changes within an industry over time. We also consider whether our results are robust to aggregating to weekly periods rather than monthly periods and controlling for facility-by-quarter fixed effects, which allow us to control for seasonality in facility-level production decisions and other factors. Consistent with the findings of our falsification exercise, we find no evidence that omitted variables drive our core results.

As noted, absent omitted variable concerns, we assume that empirical relationships between complaints and regulatory outcomes identify regulatory responses to new information on pollution concerns otherwise unknown to the regulator. We acknowledge the possibility that empirical relationships could reflect a mechanism where complaints contain no new information but instead increase pressure on regulators to respond to pollution information already available, as in Buntaine et al. (Forthcoming). Although we are unable to fully disentangle empirical mechanisms, we believe this conjecture is unlikely to drive our results. As discussed in more detail in the next section, we estimate a specification in which we control for a salient measure of contemporaneous pollution observable to the regulator, excess emissions events. Excess emissions events are significant pollution releases that occur during facility start-up, maintenance, and shut-down. Results are unchanged when we control for excess emissions events.

5 Results

5.1 Regulatory Responses

Figure 3 presents local projection estimates characterizing the dynamic relationship between citizen complaints and the monitoring behavior of the regulator. In Figure 3a, we precisely estimate that a citizen complaint against a facility is associated with a 51 percentage point increase in the likelihood of receiving an investigation that month, compared to the month prior to receiving the complaint. We estimate a 22 percentage point increase in the likelihood of receiving an investigation one month after the complaint. Investigations are uncommon (i.e., the sample mean probability is 0.026) so these represent large effects. We estimate that the likelihood of receiving an investigation returns to trend after two months.[22]

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[22]In our baseline specification, we estimate small and precise reductions in the likelihood of an investigation prior to receiving a complaint. While these estimates are close to zero, we estimate a specification with twelve months of lagged complaints to account for potential serial correlation (Figure A2). With the inclusion of lags, the estimated coefficients for β^t in the months leading up to the complaint are statistically insignificant, suggesting that the small deviations in our baseline specification are unlikely to be an important source of confounding variation. The negative coefficients in the months after the complaint could suggest some degree

Figure 3a estimates the association between receiving a complaint and investigations of any type. In Figures 3c and 3d, we estimate the relationship between complaints and complaint investigations (i.e., those directly linked to a complaint) separately from the relationship between complaints and non-complaint investigations (i.e., those that arise for reasons other than a complaint). In Figure 3c, we estimate that a citizen complaint is associated with a 59 percentage point increase in the likelihood of a complaint-investigation in the month of the complaint and a 23 percentage point increase the following month. In short, TCEQ investigates almost all complaints that fall under its jurisdiction. In Figure 3d, we estimate that a citizen complaint is also associated with a one to three percentage point increase in the likelihood of a non-complaint investigation for up to 6 months following the complaint. While smaller than the estimated coefficients in Figure 3c, these represent economically meaningful effects of 42 to 125 percent when evaluated at the sample mean. This pattern is consistent with an extended period of increased regulatory scrutiny after a complaint.

Figure 4 presents local projection estimates for the likelihood of receiving a notice of violation (NOV) (Figure 4a) and the likelihood of receiving a notice of enforcement (NOE) (Figure 4c). We estimate an increase in the likelihood of both NOVs and NOEs in the months following a complaint. For example, we estimate that a complaint is associated with a 6 percentage point increase in the probability of an NOV and a one percentage point increase in the likelihood of an NOE two months after the complaint. Given sample mean NOV and NOE probabilities of 0.0032 and 0.00048, respectively, these are large effects.[23]

Table 1 summarizes results intended to explore concerns about time-varying omitted variables. Panel A presents results investigating the robustness of the relationship between a complaint incident in month t and the likelihood of an investigation in month t. Panel B presents results investigating the robustness of the relationship between a complaint incident in month t and the likelihood of an NOV in month $t+2$. Panel C presents results investigating the robustness of the relationship between a complaint incident in month t and the likelihood of an NOE in month $t+2$. These time horizons were chosen to match the peak effects estimated in Figures 3a, 4a, and 4c, and figures corresponding to results in Table 1 document more complete dynamic effects.

Table 1, column 1 presents estimates from our main specification for comparison. In column 2, we present estimates from our falsification test. Graphical evidence on falsification test results is presented in Figures 3b, 4b, and 4d. If empirically relevant, this exercise

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of harvesting (i.e., temporal displacement of investigations) but the estimated coefficients remain small in magnitude.

[23]We estimate a slight lag in NOE response compared to NOV response. This is consistent with TCEQ's enforcement processes, where NOEs require additional administrative oversight.

should identify the effect of confounding factors that are associated with both the likelihood of receiving a complaint and regulatory attention. We estimate a precise null association between a facility receiving a complaint outside of TCEQs jurisdiction and the likelihood of an investigation, an NOV, or an NOE. Taken at face value, point estimates indicate that referred complaints are associated with a 0.4 percentage point increase in the likelihood of receiving an investigation, a 0.5 percentage point increase in the likelihood of receiving an NOV, and a -0.08 percentage point decrease in the likelihood of receiving an NOE. [24]

In Table 1, column 3, we directly control for excess emissions events. Our estimates are almost identical. In column 4 and Figure A4a, we show results are robust to the inclusion of county-by-month fixed effects, which capture considerations like local weather and enforcement resources. In column 5 and Figure A4b, we see results are also robust to adding industry-by-month fixed effects, which capture within-year variation in market conditions.

In addition to the results presented in Table 1, we present additional sensitivity analyses in Appendix A. Our results are robust to aggregating to weekly periods rather than monthly periods (Figure A5). Analysis at the weekly level gives us additional variation to control for facility-by-quarter fixed effects, which allow us to control for seasonality in facility-level decisions and outcomes. We also note that our local projections estimates are qualitatively and quantitatively similar to estimates from a distributed lag model (Figure A6).[25]

5.2 Regulatory Implications

The overall implications of our results for efficiency and distribution depend on three additional questions. First, are there differences in the return to monitoring activities triggered by complaints compared to the returns from standard monitoring activities? Second, what is the dynamic relationship between complaints and monitoring behavior at facilities that are not the subject of complaints? That is, do we observe any evidence of crowd out or crowd in at other facilities on the margin (Evans et al., 2018)? Third, do regulators respond differently to complaints against facilities located in communities with different characteristics? That is, are TCEQ responses to complaints consistent with procedural justice guidelines where complainants are treated equally regardless of race and income?

Does the return to monitoring activities associated with complaints differ from the return to standard monitoring activities not associated with complaints? We first reiterate that

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[24]Falsification test results are not driven by systematic differences between facilities that did and did not receive complaints that were referred to other agencies. We show this by replicating our main analysis on the sub-sample of facilities that received at least one referred complaint. Our estimates on this restricted sample are statistically indistinguishable from our main results (Figures A3a, A3b, and A3c).

[25]This approach also assumes conditional independence. The similarity in findings suggest that serial correlation concerns are not a first-order concern in this context.

TCEQ investigations associated with complaints are different from routine non-complaint investigations in that almost all sample investigations triggered by a complaint involve on-site activities rather than off-site file reviews. By contrast, our data indicate only about 40 percent of sample investigations conducted for other purposes involve on-site activities. In light of this, to explore the returns to monitoring question, we remove off-site non-complaint investigations from our sample and consider a more "apples to apples" comparison.[26] We estimate that an investigation triggered by a complaint is associated with a 6-8 percentage point increase in the likelihood of an NOV in each of the two months following the investigation (Figure A7a). By contrast, an on-site investigation initiated for other reasons is associated with a 2-3 percentage point increase in the likelihood of receiving an NOV in each of the two months following the investigation (Figure A7b). We estimate that an investigation triggered by a complaint is associated with a 1 percentage point increase in the likelihood of an NOE in each of the two months following the complaint investigation (Figure A7c). By contrast, we fail to detect a significant relationship between an on-site investigation initiated for another reason and the likelihood of an NOE in the months following the investigation (Figure A7d). In sum, in our data, investigations triggered by complaints are economically and statistically more likely to be associated with outcomes involving formal notices of violation and enforcement, compared to routine on-site investigations.

The preceding findings are not the results of complaint investigations uncovering more, but less severe, violations. Supplemental data provide information on the severity of violations detected during investigations. This measure characterizes violations as Category A (most severe), Category B (moderately severe), or Category C (least severe).[27] We estimate that an investigation triggered by a complaint is associated with higher likelihood of a documented violation of any severity, relative to an investigation initiated for another reason (Figure A8). Most notably, we estimate that an investigation triggered by a complaint is associated with a 4 percentage point increase in the likelihood of a documented Category A (most severe) violation. By contrast, an on-site investigation initiated for another reason is associated with a 0.5 percentage point increase in the likelihood of a documented Category A (most severe) violation. In short, our evidence indicates that investigations associated with complaints uncover more severe violations than investigations initiated for other reasons.

Do complaints crowd in or crowd out investigations at other facilities? First, we examine

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[26]Our on-site indicators are based on the subset of investigations for which we have complete activity code information. In addition to dropping non-complaint related investigations that didn't involve on-site activities, we also drop the 25% of investigations for which we do not have information about whether an on-site visit occurred.

[27]TCEQ (2020) provides examples of each violation category. As an example, previously described excess emissions events are category A violations.

the relationship between the number of complaints against *other* entities in the same regulatory region and month and the likelihood that a sample facility receives an investigation.[28] We focus on region as that is the jurisdiction of record and investigator assignments occur within region. Second, we examine spillovers within industry. Specifically, we estimate the relationship between the number of complaints against *other* facilities in the same industry (i.e., defined by 2-digit Standard Industrial Classification code) and month and the likelihood that a sample facility is investigated.[29] In both models, we condition on whether or not the facility itself receives a complaint as in equation 1. We find no evidence of crowd out or crowd in on either margin; estimated coefficients are very close to zero and statistically insignificant (Figure A9). On average, investigations of complaints targeting a given entity within the same regulatory region, or within the same industry, do not reduce the likelihood of investigations at non-targeted Title V / NSR facilities. We acknowledge that our failure to detect spillovers along these two dimensions does not rule out the possibility of resource crowd out elsewhere in the larger TCEQ regulatory system.

Do regulators respond differently to complaints in different areas? We explore heterogeneity in the relationship between complaints and regulatory response. In Figure A10a and Figure A10b, we see that the likelihood of a complaint investigation and the likelihood of an NOV following a complaint are similar for complaints against facilities in zip codes with above and below median poverty levels. If anything, we document modest evidence that complaints against facilities in lower income areas result in marginally higher probabilities of investigation and notices of violation. In Figures A10c and A10d, we see that the likelihood of a complaint investigation and the likelihood of a NOV following a complaint are similar for complaints against facilities in zip codes with above and below median shares of white residents. If anything, we document modest evidence that complaints against facilities in zip codes with lower shares of white residents result in marginally higher probabilities of notices of violations. In Figures A10e and A10f, we see that the likelihood of a complaint investigation and the likelihood of a NOV following a complaint are similar for complaints against facilities in zip codes with above and below median shares of population living in urban areas. In sum, we find no evidence that regulators respond differently to complaints about facilities located in different areas, at least along dimensions of income, race, and urbanicity.

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[28]Entities include other sample facilities, non-sample facilities, and private parties that are the subject of complaints.

[29]For within industry spillovers, we focus on the sub-sample of 14,249 facilities assigned to a single industry, which represent about 87% of the sample facilities with non-missing information on industry.

5.3   Back-of-the-Envelope Calculation

Our results show that, on average, investigations in response to citizen complaints detect more, and more serious, violations than routine (i.e., non-complaint) monitoring activities. This does not, however, necessarily imply that citizen complaints increase social welfare. While data constraints preclude evaluating the total welfare effects of citizen complaints, we are well positioned to explore the regulatory cost implications. We ask: what are the budgetary implications of replacing complaint investigations with non-complaint investigations while holding fixed the total expected benefits? In other words, how much more would TCEQ have to spend to deliver the same expected benefits if they were to eliminate citizen complaints from the regulatory process?

Answering this question requires us to make a number of simplifying assumptions. First, we assume that TCEQ's costs of maintaining the complaint infrastructure are small. Second, we assume that the consequences any given violation are the same whether the violation is detected through a complaint investigation or a non-complaint investigation. Third, we assume that, aside from the labor costs to TCEQ of conducting an investigation, there are no differences in regulatory costs between complaint and non-complaint investigations.

Under these assumptions, the regulatory cost implications of our analysis depend on two differences between a complaint and a non-complaint investigation: (1) the difference in the likelihood of uncovering a violation, and (2) the difference in the labor costs of conducting the investigation. Our empirical results inform point (1). In the previous section, we estimated that complaint investigations are on average 2 to 4 times more likely to result in a notice of violation than on-site non-complaint investigations. To inform point (2), we collected supplemental data on the labor effort and labor costs associated with TCEQ investigations, which reflect time spent on investigation preparation, the investigation itself, post-inspection analysis and paperwork, necessary travel, and quality assurance hours.[30] These data show that the median complaint investigation requires 10.5 labor hours and the median on-site non-complaint investigation requires 7 labor hours. The average hourly cost of an investigation is $48.50. As such, we calculate labor costs of $510 for the median complaint investigation and $340 for the median on-site non-complaint investigation.

Taken together, we find that complaint investigations are somewhat more costly but significantly more "productive" than on-site non-complaint investigations on average. A simple back-of-the envelope calculation suggests that it would cost 1.33 to 2.66 times more to deliver the same expected benefit of a complaint investigation using on-site non-complaint

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[30]We obtained these data via a public information request to TCEQ (PIR 23-83999). We restrict the data to investigations that occurred between 2003 and 2019 and that can be linked to the 23,100 facilities in our balanced panel sample of Title V and NSR facilities.

investigations. Alternatively, we note again that it would require 2 to 4 on-site non-complaint investigations to generate the equivalent benefits of a single complaint investigation. In an average sample year, TCEQ conducted 629 complaint investigations of Title V and NSR facilities and 10,084 non-complaint investigations. Assuming all non-complaint investigation are on-site, we obtain an upper bound estimate of TCEQ's total annual monitoring budget for sample facilities of ~$3.75 million. Based on this estimate and holding total expected benefits fixed, we calculate that TCEQ would need to increase its monitoring budget for Title V and NSR facilities by at least 3-14% if it were to replace all complaint investigations with on-site non-complaint investigations.

6   Conclusion

Using evidence from a nationally representative survey, we show that the general public believes that citizen complaints promote procedural justice and public transparency. These attitudinal results stand on their own. We also find that, on average, the general public believes that citizen complaints enhance regulatory efficiency and promote environmental justice. Assessing the validity of these latter beliefs requires an analysis of how regulators respond to complaints and what they find when they do respond.

Using comprehensive data from Texas between 2003 and 2019, we document that citizen reports of pollution concerns increase complaint investigations, non-complaint investigations, notices of violation, and notices of enforcement for up to 6 months. We show that an on-site investigation follows the overwhelming majority of citizen complaints. These investigations detect more – and more serious – violations than routine monitoring activities.

We note caveats. First, lessons from Texas will not necessarily apply elsewhere. To the best of our knowledge, Texas's guidelines for gathering and responding to citizen complaints parallel those of other states. Furthermore, Texas is an important context for considering pollution oversight as it contains roughly one-fifth of the country's major emitters under the Clean Air Act. Nevertheless, external validity is not guaranteed. Second, a causal interpretation of regulatory analysis results assumes conditional independence. Although we find no evidence that omitted variables drive our core results, we cannot fully rule out residual time-varying idiosyncratic shocks that influence both complaints and regulatory scrutiny for reasons other than the pollution concerns identified in the complaints. Third, while we fail to detect crowd out or crowd in of citizen complaints among other sample facilities, our analysis of regulatory spillovers is constrained to sample facilities. Investigations of citizen complaints may affect TCEQ efforts elsewhere within its large regulatory universe. Finally, we do not conduct a full welfare analysis of citizen complaints. As noted above, we are able

to document significant implications for regulatory costs.

In addition to contributing to the academic literature, our results inform recent policy discussions on the role of citizen complaints in environmental regulation. For example, Texas Senate Bill 471, which went into effect on September 1, 2023, changed regulatory guidelines to recommend that TCEQ forgo investigations of complaints when the relevant issues "may be addressed during other commission activities" (Texas Senate Bill 471, 2023). If this guidance shifts TCEQ efforts away from investigating citizen complaints, all else equal our results predict a significant reduction in the detection of noncompliance with consequences for human health and environmental quality.[31] If, instead, TCEQ attempts to hold benefits constant, our back-of-the-envelope calculations suggest important increases in regulatory costs. Because complaint investigations uncover more and more severe violations than routine investigations, fully eliminating citizen complaint investigations while holding benefits constant would require an increase in overall agency spending of at least 3 to 14%.

Overall, our research demonstrates that citizen complaints are popular with the public and play an important role in pollution oversight. Citizen complaints support the legal mandate of environmental agencies to uncover and sanction environmental violations and do so in a way that is distributionally neutral and enhances regulatory efficiency.

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[31]Hollingsworth et al. (2021) explore the damages of excess emissions events and find that they are responsible for 35 deaths among the elderly in Texas each year.

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Figures and Tables

Figure 1: Respondents' Attitudes towards Environmental Citizen Complaints

(a) Better information

(b) Environmental justice

(c) Basic rights

(d) Wastes resources

(e) Undue influence
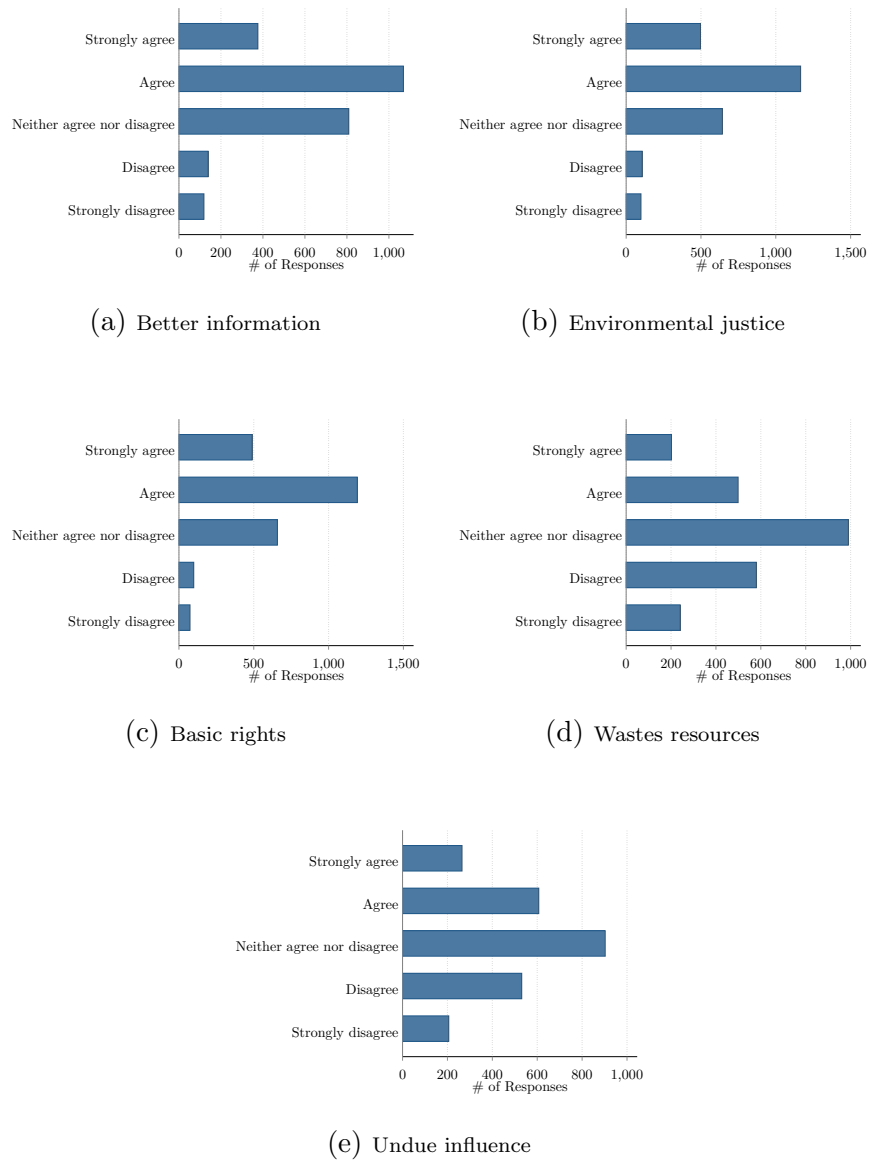
NOTES: This Figure documents the degree to which respondents agreed that citizen reports of pollution concerns: (a) Provide better information on local pollution problems than the Enforcement Agency (EA) gets during its inspections; (b) Promote environmental justice and the protection of vulnerable populations in the community; (c) Promote basic rights, open government, transparency, and accountability; (d) Involve false or bad information that wastes the EA's resources; and (e) Allow environmental activists and environmental organizations to have too much influence on the EA.

Figure 2: Distribution of Complaints by Year, Month and Day-of-the-Week
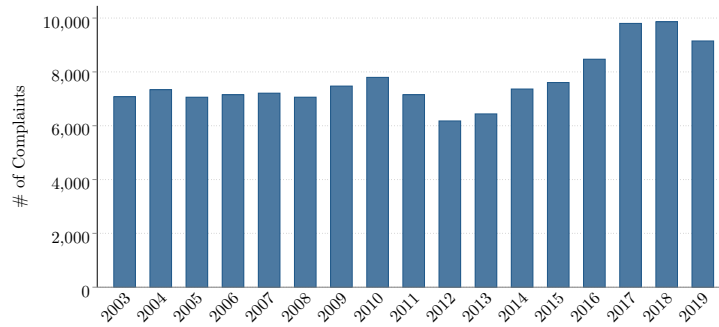
(a) Complaints by Year
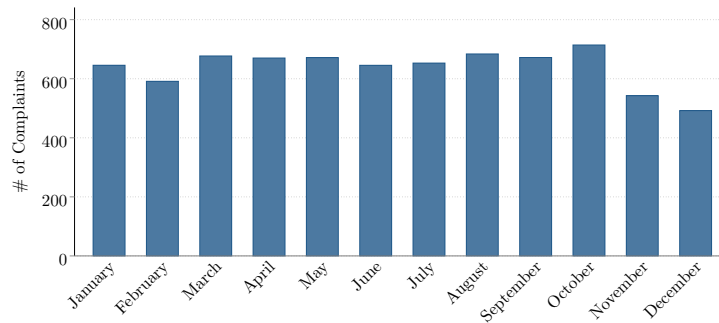
(b) Complaints by month
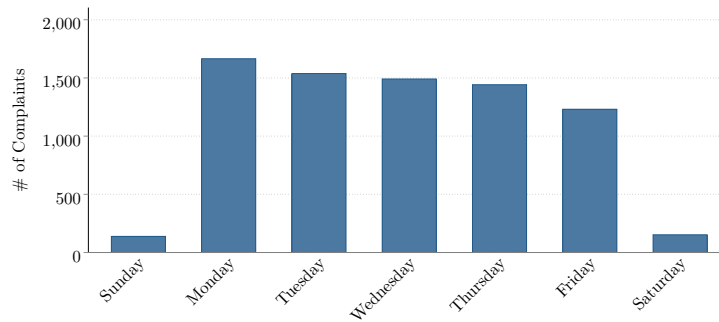
(c) Complaints by day-of-the-week

NOTES: Panel (a) reports the number of complaints received by TCEQ in each year between 2003 and 2019. Panel (b) reports the average number of complaints received each month between 2003 and 2019. Panel (c) reports the average number of complaints received on each day-of-the-week between 2003 and 2019.

Figure 3: The Association between a Citizen Complaint and the Likelihood of an Investigation over Time

(a) Any investigation

(b) Any investigation (placebo)

(c) Complaint investigation

(d) Non-complaint investigation
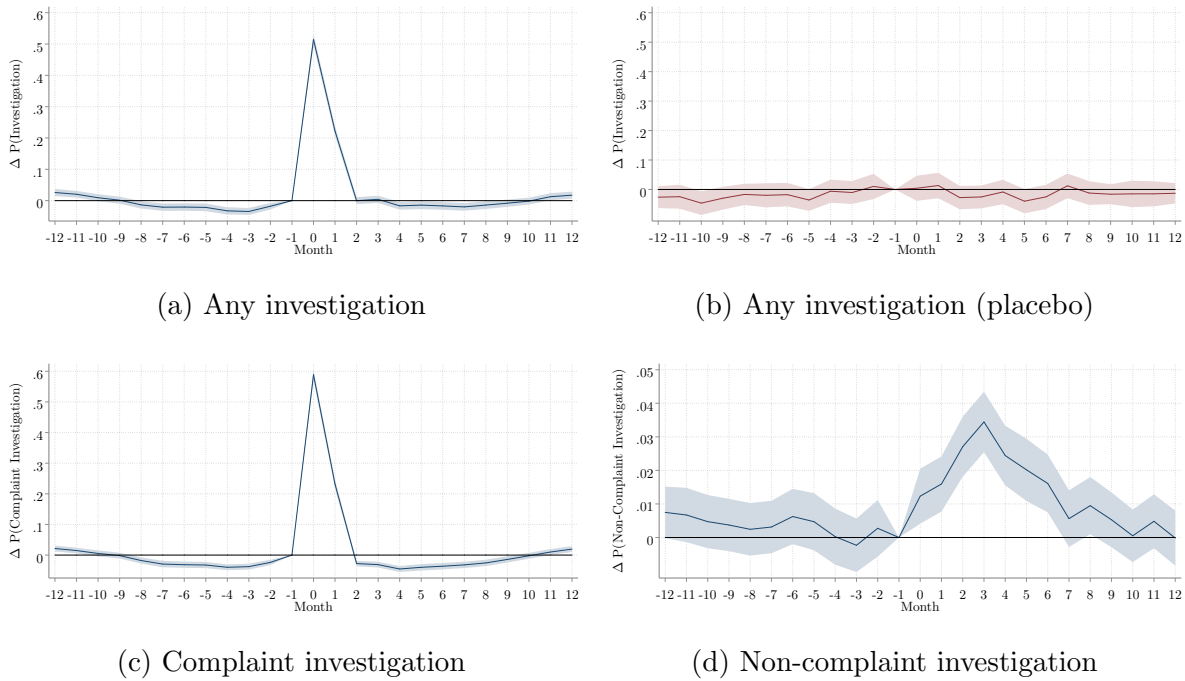
NOTES: This Figure plots the association between TCEQ receiving a citizen complaint and the likelihood of an investigation in each of the 12 months on either side of the event. Estimates capture the change in the likelihood of an investigation relative to the month prior to the complaint. Each estimate is the result of a separate regression, using the local projections estimator (equation 1). Shading reflects the 95 percent confidence interval. Standard errors are clustered at the facility level. Panel (a) reports estimates for any investigation. Panel (b) reports estimates from the falsification exercise, where the complaints recieved are outside of TCEQs jurisdiction. These complaints are referred to other agencies. Panel (c) show estimates for complaint investigations and panel (d) reports estimates for non-complaint investigations.

Figure 4: The Association between a Citizen Complaint and the Likelihood of an NOV and NOE over Time

(a) Notice of Violation

(b) Notice of Violation (placebo)

(c) Notice of Enforcement

(d) Notice of Enforcement (placebo)
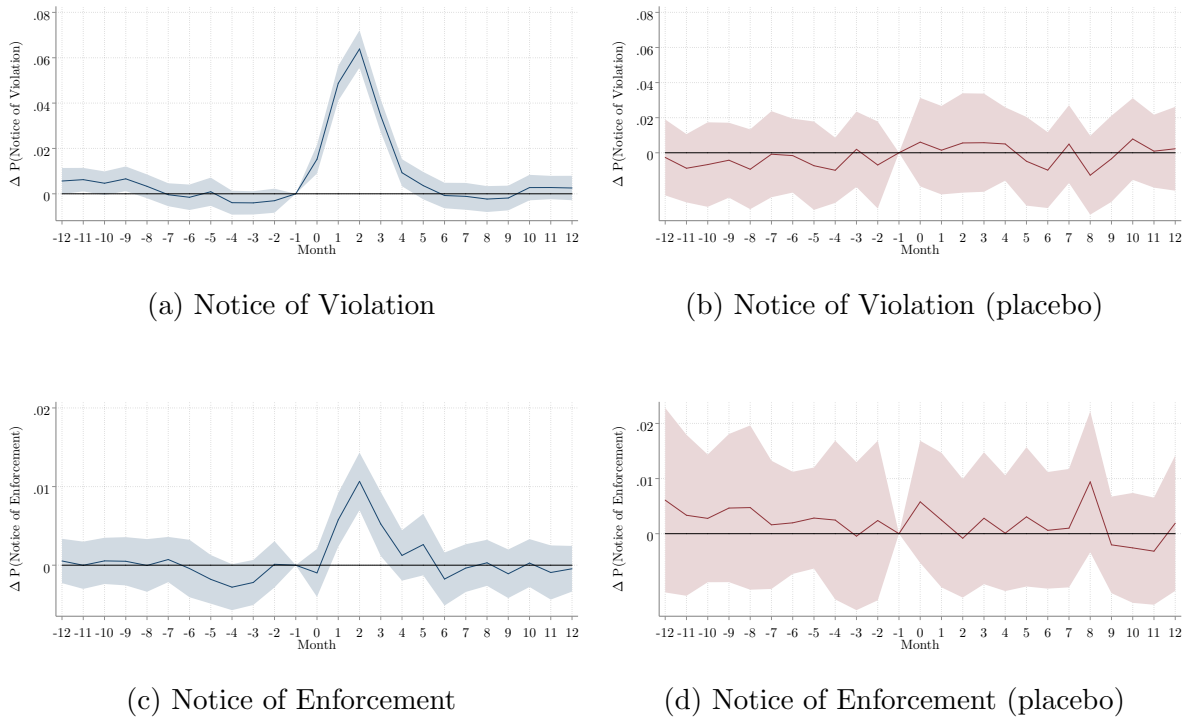
NOTES: This Figure plots the estimated relationship between a citizen complaint in period 0 and the likelihood of an NOV (panel a) or NOE (panel c) in each of the 12 months on either side of the event. Panels (b) and (d) report estimates from the falsification exercise, where the receipt of complaint is outside of TCEQs jurisdiction. Estimates capture the change in the likelihood of an NOV or NOE relative to the month prior to the complaint. Each estimate is the result of a separate regression, using the local projections estimator presented in equation 1. Shading reflects the 95 percent confidence interval. Standard errors are clustered at the facility level.

Table 1: The Contemporaneous Association between Complaint Incidents and the Likelihood of an Investigation

	(1)	(2)	(3)	(4)	(5)
Panel A: Δ P(INVESTIGATION$_t$)					
Complaint Incident$_t$	0.523***	0.00408	0.523***	0.520***	0.502***
	(0.00946)	(0.0218)	(0.00946)	(0.00954)	(0.0110)
Panel B: Δ P(NOV$_{t+2}$)					
Complaint Incident$_t$	0.0655***	0.00559	0.0654***	0.0659***	0.0631***
	(0.00439)	(0.0144)	(0.00439)	(0.00440)	(0.00508)
Panel C: Δ P(NOE$_{t+2}$)					
Complaint Incident$_t$	0.0107***	-0.000833	0.0106***	0.0107***	0.0103***
	(0.00204)	(0.00549)	(0.00204)	(0.00207)	(0.00248)
Placebo Treatment	No	Yes	No	No	No
Facility-Year Fixed Effects	Yes	Yes	Yes	Yes	Yes
Month-of-Data Fixed Effects	Yes	Yes	Yes	Yes	Yes
Emissions Event Controls	No	No	Yes	Yes	Yes
County-Month Fixed Effects	No	No	No	Yes	Yes
Industry-Month Fixed Effects	No	No	No	No	Yes
Observations	4,158,000	4,158,000	4,158,000	4,012,920	2,949,660

NOTES: Significance levels are indicated as * 0.10 ** 0.05 *** 0.01. Coefficients are estimated using a balanced panel. Panel A presents the contemporaneous association between receiving a complaint and the likelihood of a regulatory investigation of any kind by TCEQ. Panel B presents the association between receiving a complaint and the likelihood of receiving a Notice of Violation two months later. Panel C presents the association between receiving a complaint and the likelihood of receiving a Notice of Enforcement two months later. We use these time horizons as they represent the largest estimate between complaint incidents and the outcome of interest. Column (1) reflects our baseline estimate. Column (2) presents results from our placebo treatment – complaints received by TCEQ about a facility that are outside of TCEQs jurisdiction. The precise zero estimate indicates that our main results are not driven by within-year facility-specific factors that would inherently lead to increased regulatory scrutiny and a higher likelihood of receiving a complaint. Column (3) controls for coinciding emissions events, which may induce increased regulatory scrutiny while being correlated with complaints. Column (4) incorporates county-by-month-of-data fixed effects controlling for within-year county-specific shocks and trends. Column (5) includes sector-by-month-of-data fixed effects controlling for within-year industry-specific shocks and trends. The smaller sample sizes in columns 4 and 5 is due to the absence of county and sector information for some facilities.

Online Appendices – Not for Publication

Contents

A Additional Results and Robustness Tests

In this Appendix we present additional results and robustness tests to support our main analysis.

Table A1: Sample Summary Statistics

Variable Name	Mean	Standard Deviation
P(air complaint)	0.0021	0.046
P(air investigation)	0.026	0.16
P(air complaint investigation)	0.0021	0.045
P(air non-complaint investigation)	0.024	0.15
P(air notice of violation)	0.0032	0.056
P(air notice of enforcement)	0.00048	0.022
P(excess emissions event)	0.0075	0.086
Air complaints on other entities in the same region	22.40	28.29

NOTES: With the exception of the last, all variables take the value of one if the facility received at least one of the indicated outcomes in the month and zero otherwise. Sample size is 4,712,400 and reflects 23,100 facilities over 204 months. The final variable is the number of air complaints received by other facilities in the same regulatory region and month. Sample size for the final variable is 4,548,792 due to missing information on geographic location for 802 facilities.

Figure A1: Number of Title V/NSR facilities by Zip Code
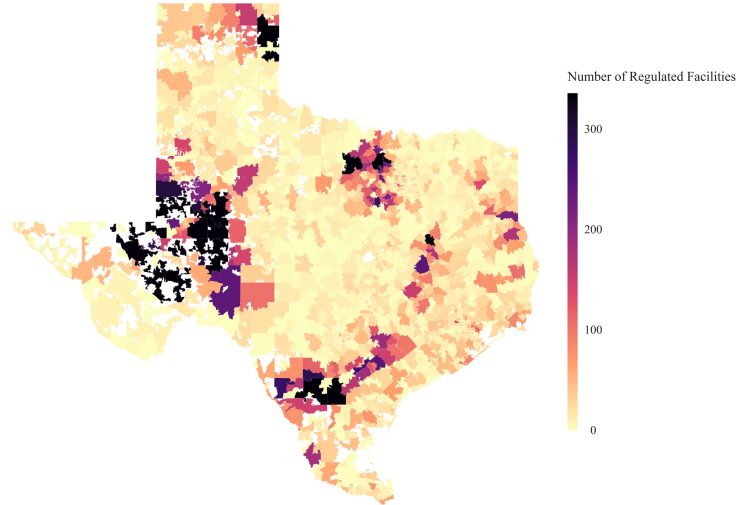
NOTES: The number of Title V/NSR facilities is winsorized at the 99th percentile to aid visualization. The maximum number of Title V/NSR facilities in a zip code is 1,064.

Figure A2: Inclusion of Lags
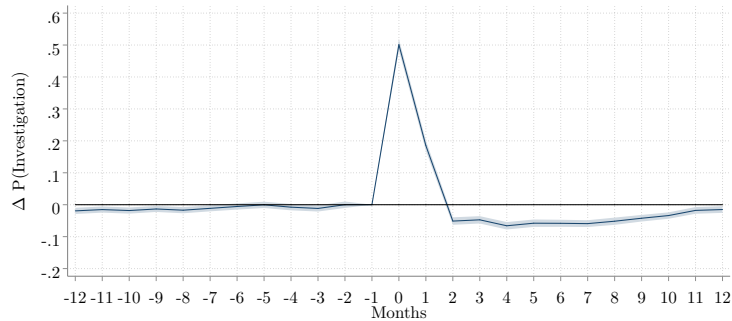
NOTES: This Figure plots the estimated relationship between a citizen complaint and the likelihood of an investigation in each of the 12 months on either side of the event. Estimates capture the change in the likelihood of an investigation relative to the month prior to the complaint. Each estimate is the result of a separate regression, using the local projections estimator presented in equation 1 augmented with 12 months of lagged values of $Complaint_{it}$. Shading reflects the 95 percent confidence interval. Standard errors are clustered at the facility level.

Figure A3: The Association between receiving a Complaint and the Likelihood of an Investigation over Time (Restricted Sample of Facilities that received Referred Complaints)
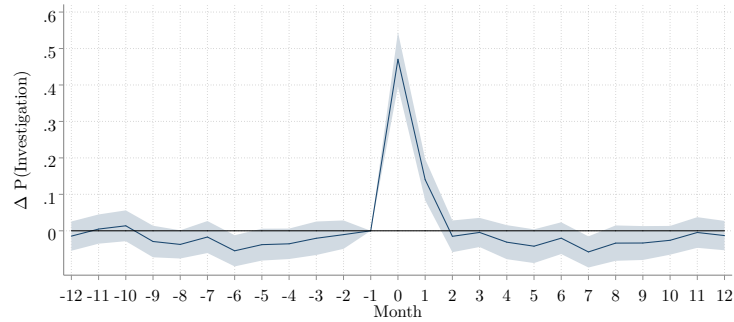
(a) Investigation
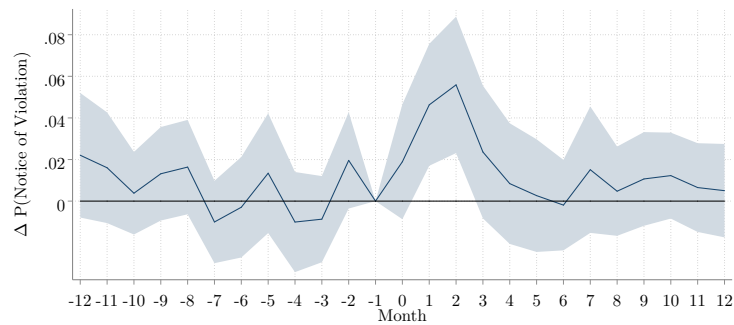
(b) Notice of Violation
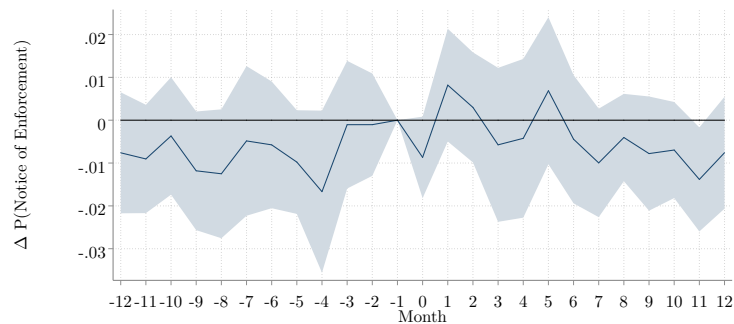
(c) Notice of Enforcement

NOTES: Panel (a) plots the estimated relationship between a citizen complaint and the likelihood of an investigation in each of the 12 months on either side of the event. Panel (b) plots the estimated relationship between a citizen complaint and the likelihood of an NOV in each of the 12 months on either side of the event. Panel (c) plots the estimated relationship between a citizen complaint and the likelihood of an NOE in each of the 12 months on either side of the event. Estimates capture the change in the likelihood of an investigation relative to the month prior to the complaint. Each estimate is the result of a separate regression, using the local projections estimator presented in equation 1. Shading reflects the 95 percent confidence interval. Standard errors are clustered at the facility level.

Figure A4: Additional Fixed Effects
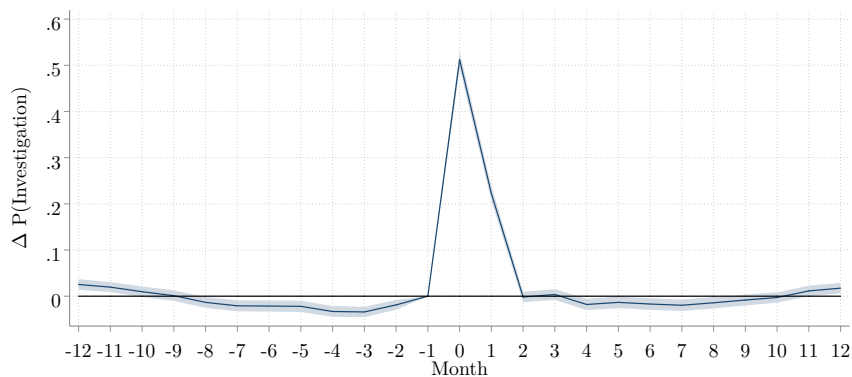
(a) County-by-month fixed effects
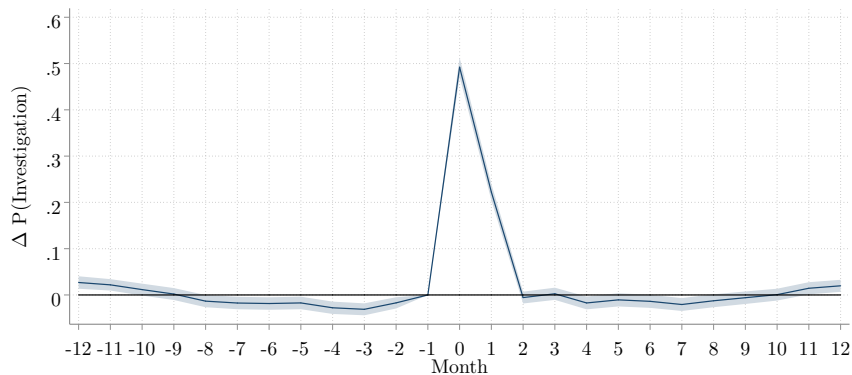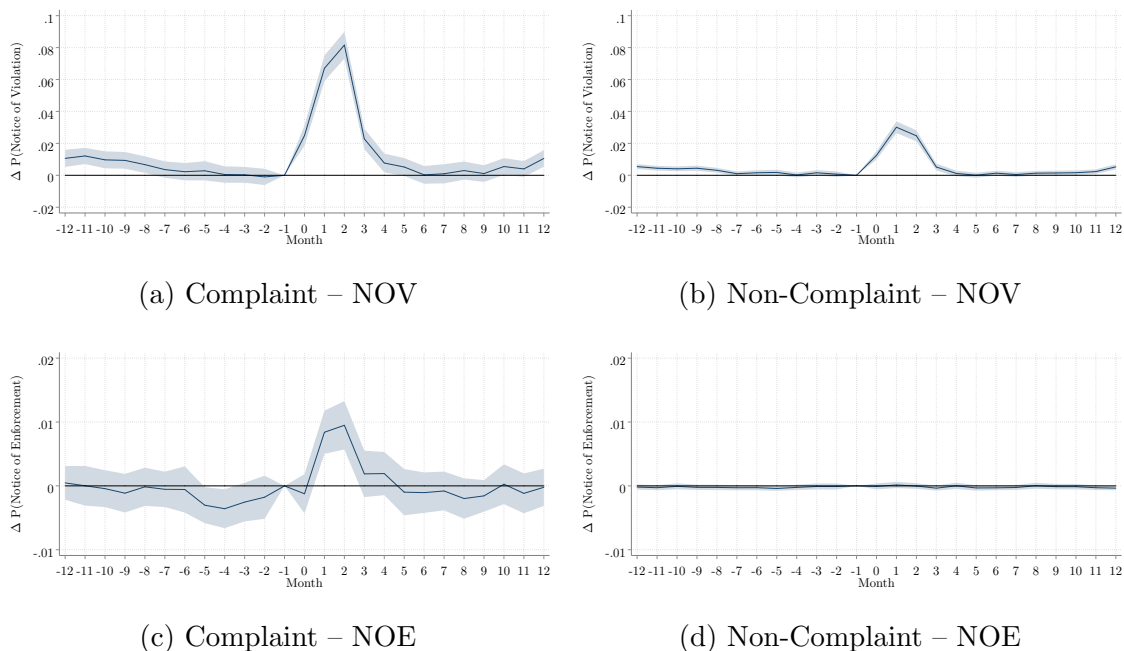

(b) County-by-month and industry-by-month fixed effects

NOTES: This Figure plots the estimated relationship between a citizen complaint and the likelihood of an investigation in each of the 12 months on either side of the event. Estimates capture the change in the likelihood of an investigation relative to the month prior to the complaint. Each estimate is the result of a separate regression, using the local projections estimator presented in equation 1. Shading reflects the 95 percent confidence interval. Standard errors are clustered at the facility level. The sample for (a) represents 22,294 unique facilities. The sample for (b) represents 16,387 unique facilities. Industry is measured by the 2-digit Standard Industrial Classification(SIC) code assigned to the facility. About 14 percent of facilities have multiple 2-digit SIC codes; we treat multiple codes as a distinct category in defining the industry-by-month fixed effects.

Figure A5: The Association Between Citizen Complaints and the Likelihood of an Investigation over Time (Week-level Panel with Different Empirical Specifications)
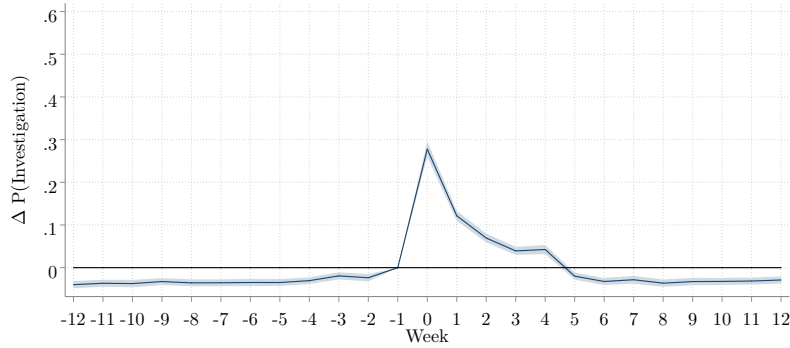
(a) Facility-by-Year Fixed Effects
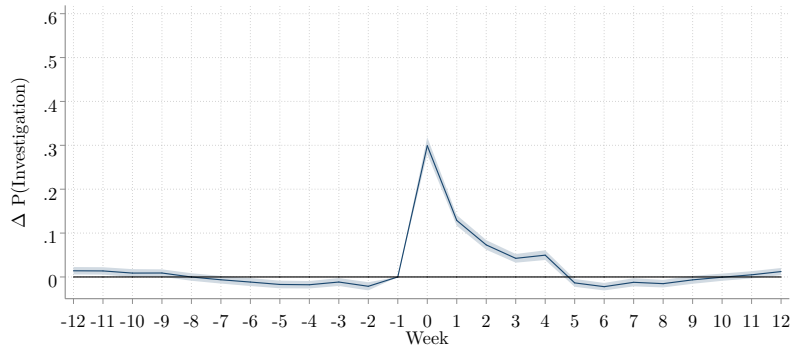
(b) Facility-by-Quarter Fixed Effects

NOTES: This Figure plots the estimated relationship between a complaint in period 0 and the likelihood of an investigation in each of the 12 weeks either side of the event. Estimates capture the change in the likelihood of an investigation relative to the week prior to the complaint. Unlike our main analysis an observation is a facility-week rather than a facility-month. Panel (a) uses facility-by-year fixed effects as in our main analysis. Panel (b) uses facility-by-quarter fixed effects. Shading reflects the 95 percent confidence interval. Standard errors are clustered at the facility level.

Figure A6: Distributed Lag Model
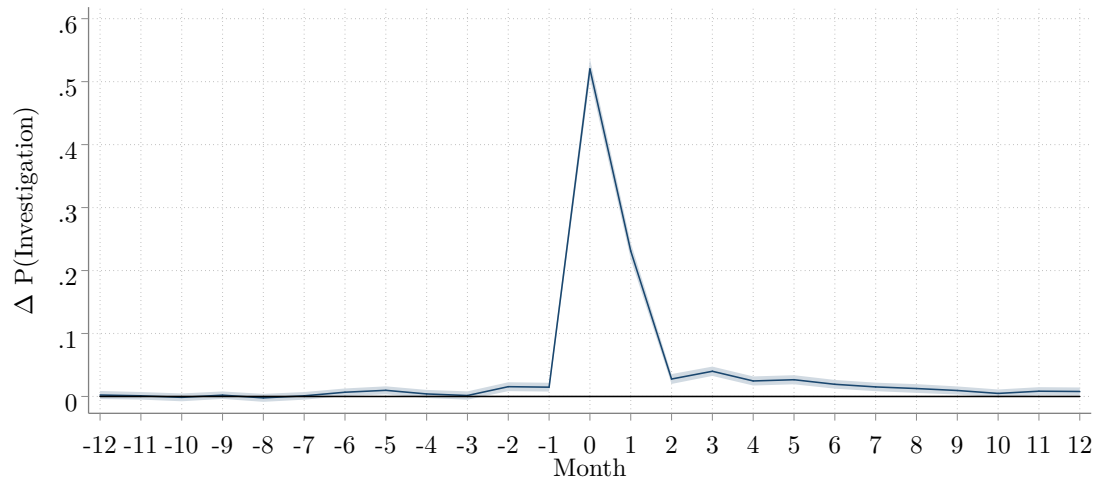
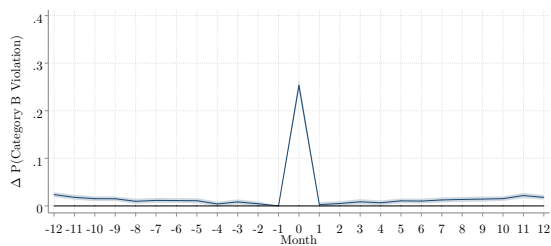NOTES: This Figure plots the estimated coefficients from a distributed lag model augmented with 12 months of leads. Standard errors are clustered at the facility level.

Figure A7: The Association between Different Investigation Types and the Likelihood of NOVs and NOEs over Time

(a) Complaint – NOV

(b) Non-Complaint – NOV

(c) Complaint – NOE

(d) Non-Complaint – NOE

NOTES: This Figure plots the estimated relationship between an investigation, either complaint or non-complaint, and the likelihood of a notice of violation or notice of enforcement in each of the 12 months on either side of the event. To increase comparability with complaint investigations, we restrict the sample of non-complaint investigations to those we know were conducted onsite. Panel (a) presents estimates of the association between an onsite complaint investigation and the likelihood of an NOV. Panel (b) presents estimates of the association between an onsite complaint investigation and the likelihood of an NOE. Panel (c) presents estimates of the association between an onsite non-complaint investigation and the likelihood of an NOV. Panel (d) presents estimates of the association between an onsite non-complaint investigation and the likelihood of an NOE. Estimates capture the change in the likelihood of a violation relative to the month prior to the complaint. Each estimate is the result of a separate regression, using the local projections estimator presented in equation 1. Shading reflects the 95 percent confidence interval. Standard errors are clustered at the facility level.

Figure A8: Different Investigation Types and the Likelihood of a Violation being Uncovered, by Violation Severity
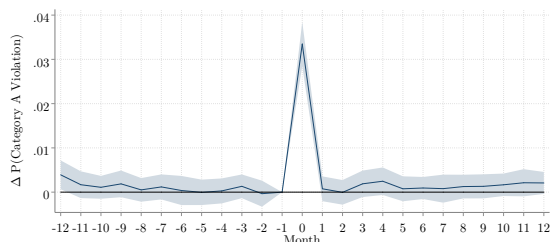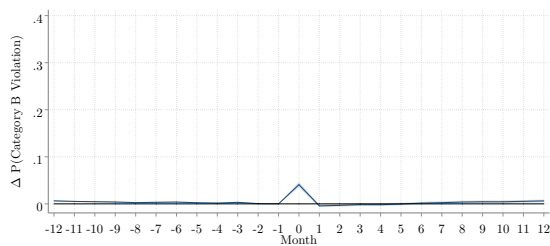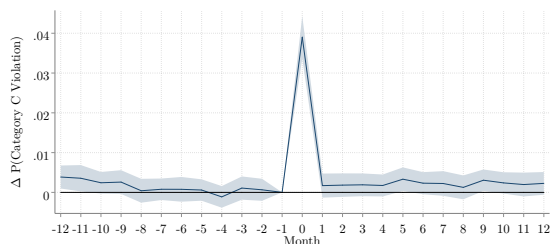

(a) Category A, Complaint
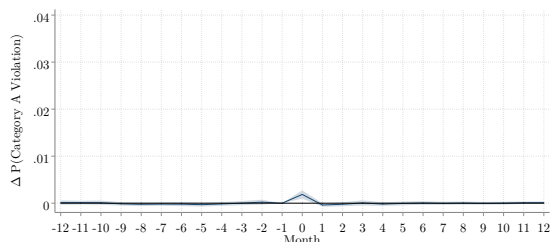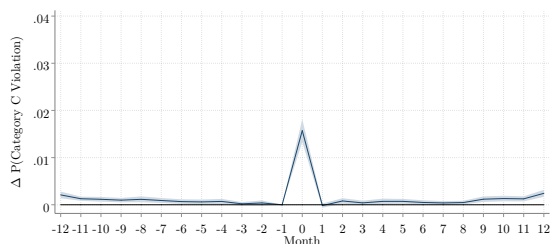
(b) Category A, Non-complaint

(c) Category B, Complaint

(d) Category B, Non-complaint
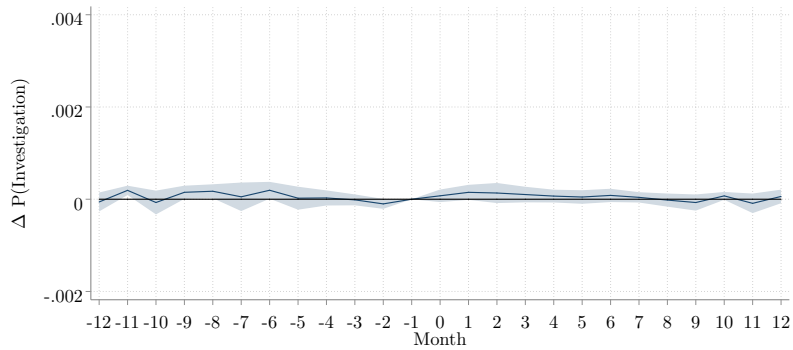
(e) Category C, Complaint

(f) Category C, Non-complaint

NOTES: This Figure plots the estimated relationship between an investigation, either complaint or non-complaint, and the likelihood of a violation of different levels of severity in each of the 12 months on either side of the event. To increase comparability with complaint investigations, we restrict the sample of non-complaint investigations to those we know were conducted onsite. Estimates capture the change in the likelihood of a violation relative to the month prior to the complaint. Each estimate is the result of a separate regression, using the local projections estimator presented in equation 1. Shading reflects the 95 percent confidence interval. Standard errors are clustered at the facility level.

Figure A9: The Association between Citizen Complaints against Other Entities in the Same Region or Same Industry and the Likelihood of an Investigation over Time
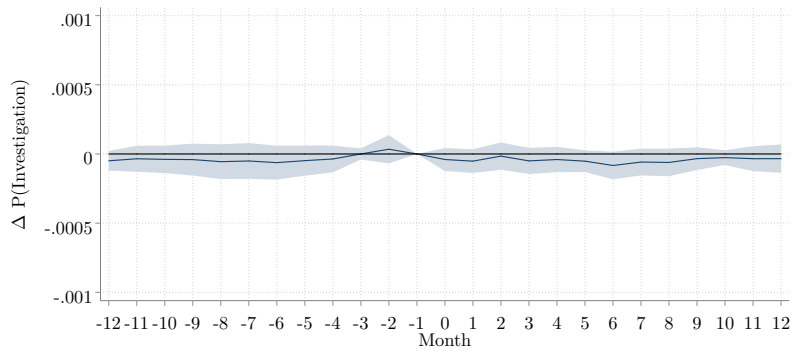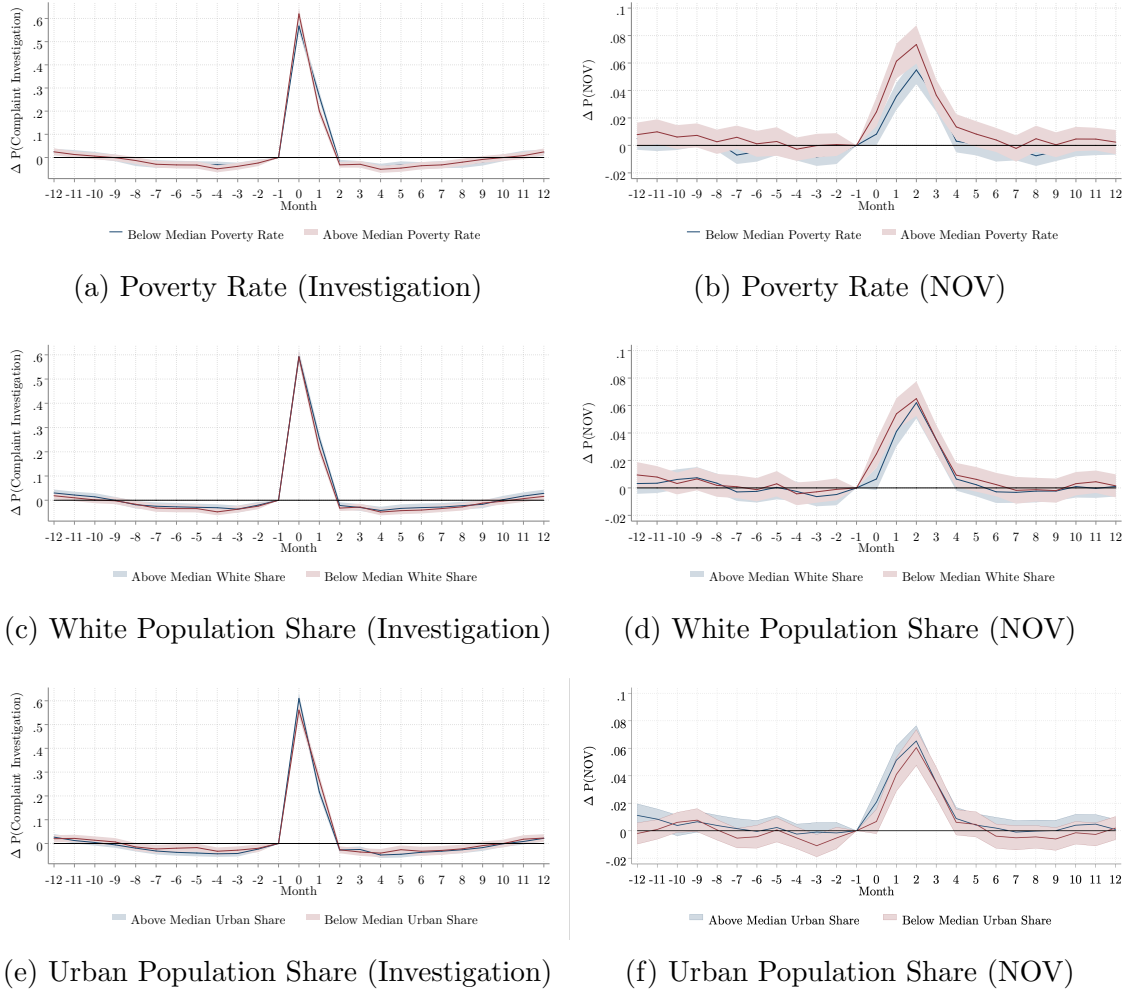

(a) Same Region

(b) Same Industry

NOTES: This Figure plots the estimated relationship between the number of citizen complaints against other entities in the same TCEQ region (panel(a)), or same industry (panel(b)), in period 0 and the likelihood of an investigation in each of the 12 months on either side of the event. Estimates capture the change in the likelihood of an investigation relative to the month prior to the complaint. Each estimate is the result of a separate regression, using the local projections estimator presented in equation 1. Specification controls for a complaint against the facility itself. Shading reflects the 95 percent confidence interval. Standard errors are clustered at the county level.

Figure A10: Heterogeneity in the Likelihood of a Complaint Investigation and Notice of Violation following a Complaint

(a) Poverty Rate (Investigation)

(b) Poverty Rate (NOV)

(c) White Population Share (Investigation)

(d) White Population Share (NOV)

(e) Urban Population Share (Investigation)

(f) Urban Population Share (NOV)

NOTES: This Figure plots the estimated relationship between a complaint in period 0 and the likelihood of a complaint investigation (Panels a and c) or a notice of violation (Panels b and d) in each of the 12 months either side of the event. Estimates capture the change in the likelihood of an investigation relative to the month prior to the complaint. We explore whether there is a differential response by investigators when a complaint is made in a zip code that is above/below the median poverty rate (Panels a and b), or in a zip code that is above/below the median share of the population that is white (Panels c and d), or in a zip code that is above/below the median share of the population living in urban area (Panels e and f). Shading reflects the 95 percent confidence interval. Standard errors are clustered at the facility level.

B Survey Appendix

In this Appendix we provide background information as well as additional supporting results, relating to our survey.

B.1 Survey Summary Statistics and Additional Results

Table B1: Survey Sample Summary Statistics

Variable Name	Mean	Standard Deviation	Observations
Panel A: Survey Responses			
Ever Reported a Pollution Concern?	0.180	0.384	2,513
Better Information	2.425	0.960	2,512
Promote Environmental Justice	2.261	0.954	2,512
Promote Transparency	2.234	0.908	2,512
Wastes Resources	3.063	1.063	2,512
Undue Influence	2.922	1.094	2,512
Panel B: Respondent Characteristics			
Female	0.532	0.499	2,490
Under 45	0.501	0.500	2,511
Some College	0.741	0.437	2,491
Hispanic	0.124	0.329	2,435
Non-Hispanic Black	0.122	0.328	2,435
Non-Hispanic White	0.694	0.460	2,435
Other Race	0.059	0.232	2,435
Republican	0.302	0.459	2,383
Democrat	0.416	0.493	2,383
Independent	0.280	0.449	2,383
Duration of Survey (minutes)	2.51	5.89	2,513

NOTES: Panel A reports survey responses to our main questions of interest. Except for "Ever Reported a Pollution Concern?", which is a binary variable, all responses are on a 5-point scale where 1 is defined as "Strongly agree", 2 is defined as "Agree", 3 is defined as "Neither agree nor disagree", 4 is defined as "Disagree" and 5 is defined as "Strongly disagree". Panel B reports respondent characteristics. All variables, other than the duration of the survey are constructed as binary variables.

Figure B1: Socio-demographic Predictors of Respondents' Attitudes towards Environmental Citizen Complaints

(a) Better information

(b) Environmental justice

(c) Basic rights


(d) Wastes resources

(e) Undue influence
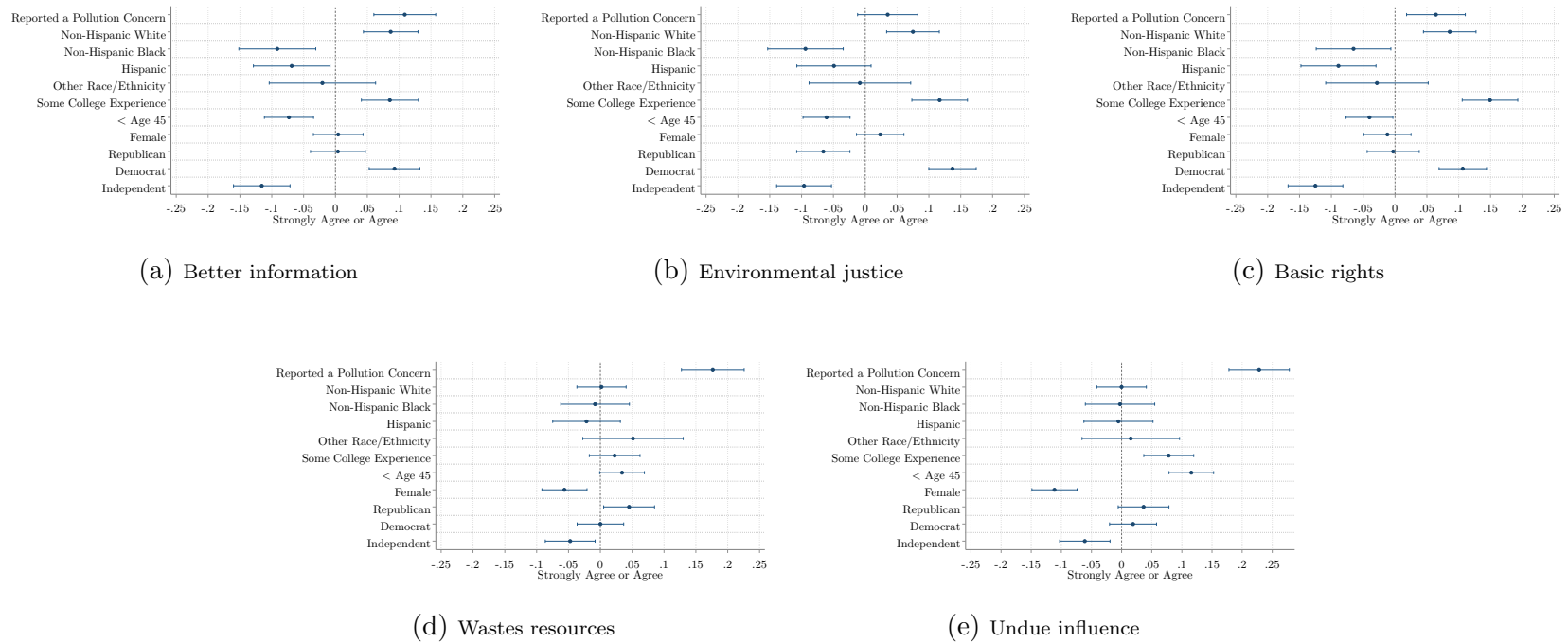
NOTES: The Figure documents the correlation between socio-demographic characteristics and the degree to which survey respondents agreed that citizen reports of pollution concerns: (a) Provide better information on local pollution problems than the EA gets during its inspections; (b) Promote environmental justice and the protection of vulnerable populations in the community; (c) Promote basic rights, open government, transparency, and accountability; (d) Involve false or bad information that wastes the EA's resources; and (e) Allow environmental activists and environmental organizations to have too much influence on the EA. Each estimate is the results of bivariate correlation between statement response and the characteristic of interest.

B.2 Texas Sample

In this section we present survey results for the 173 respondents in our survey that were based in Texas. On average, Texas respondents agreed with commonly asserted advantages of citizen participation in environmental policy (Figures B2a, B2b, B2c). 53 percent of respondents agreed or strongly agreed that citizen reports provide better information on local pollution problems than the EA gets through its own inspections (58 percent in the full sample); 10 percent disagreed or strongly disagreed (10 percent in the full sample). 58 percent of respondents agreed or strongly agreed that citizen complaints support environmental justice and the protection of vulnerable populations (66 percent in the full sample); 9 percent disagreed or strongly disagreed (8 percent in the full sample). 61 percent of respondents agreed or strongly agreed that citizen reports promote open government, transparency, and public accountability (67 percent in the full sample); 11 percent disagreed or strongly disagreed (7 percent in the full sample). We also find that, consistent with the full sample, on average, non-Hispanic white, educated, and Democrat respondents are more inclined towards agreeing with commonly asserted advantages of citizen complaints; however, again given the small sample size these results are noisily estimated.

Consistent with the full sample results, survey respondents from Texas neither clearly agreed nor clearly disagreed with commonly asserted disadvantages of citizen participation in environmental policy on average (Figures B2d, B2e). 42 percent of respondents neither agreed nor disagreed that citizen reports involve false or bad information that wastes the EA's resources (39 percent in the full sample); 28 percent agreed or strongly agreed and 29 percent disagreed or strongly disagreed (28 percent and 28 percent in the full sample). 44 percent of respondents neither agreed or disagreed that citizen complaints allow environmental activists and non-governmental organizations to have too much influence on EA activities (39 percent in the full sample); 28 percent agreed or strongly agreed and 28 percent disagreed or strongly disagreed (35 percent and 29 percent in the full sample). We also find that, consistent with our full sample results, male, more educated, and older respondents were significantly more likely to perceive that citizen reports of pollution concerns wasted resources or allowed environmental activists and NGOs to have too much influence on the environmental agency. Again, given the small sample size, these results are noisily estimated.

Figure B2: Texas Respondents' Attitudes towards Environmental Citizen Complaints

(a) Better information

(b) Environmental justice

(c) Basic rights

(d) Wastes resources

(e) Undue influence
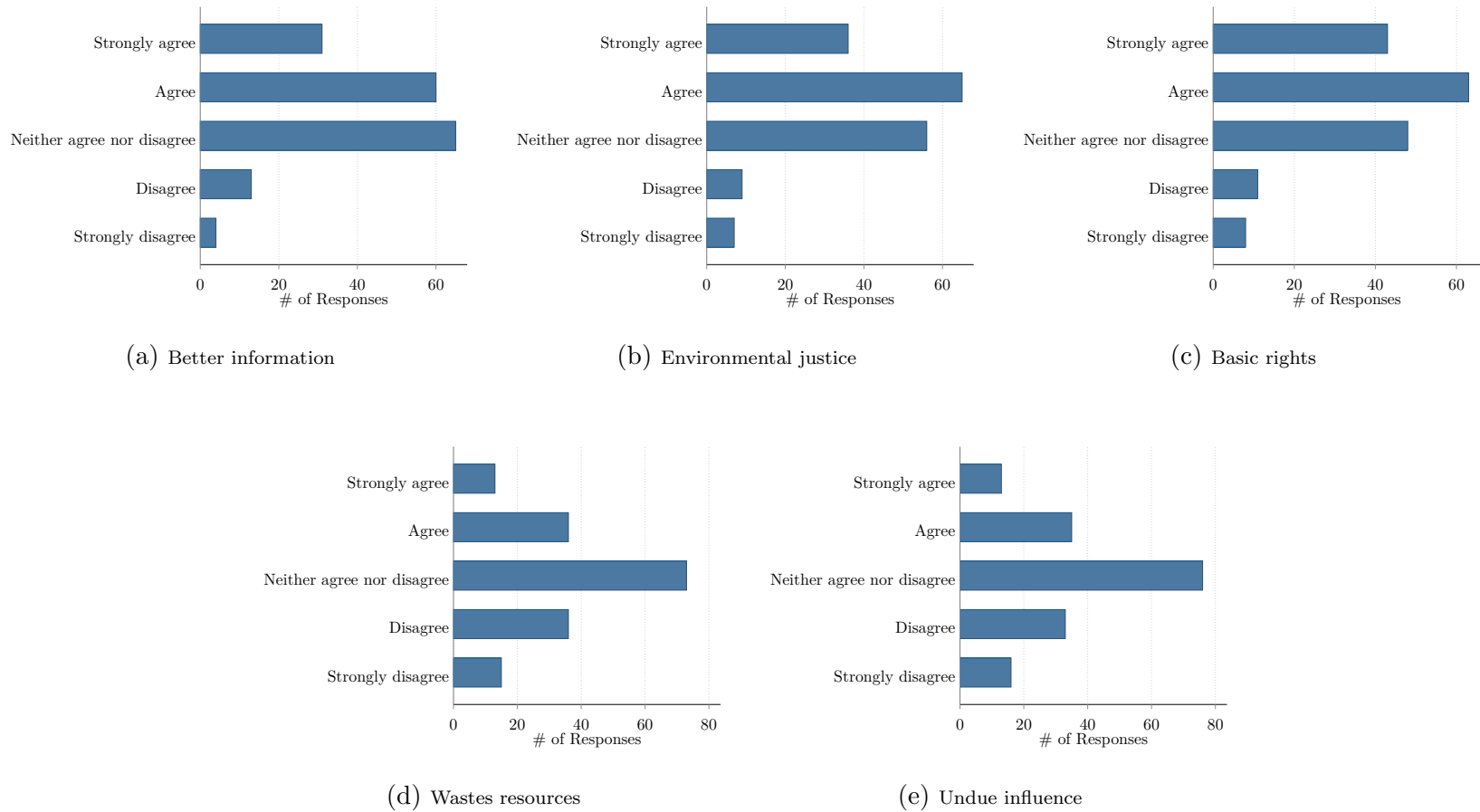
NOTES: The Figure documents the degree to which Texas respondents agreed that citizen reports of pollution concerns: (a) Provide better information on local pollution problems than the EA gets during its inspections; (b) Promote environmental justice and the protection of vulnerable populations in the community; (c) Promote basic rights, open government, transparency, and accountability; (d) Involve false or bad information that wastes the EA's resources; and (e) Allow environmental activists and environmental organizations to have too much influence on the EA.

C Complaints Data Appendix

In this Appendix we present additional descriptive analyses of environmental citizen complaints.

Figure C1: The Options for Making a Complaint to TCEQ

Figure C2: The TCEQ Online Complaints Form

Report an Environmental Problem to TCEQ

Fri Sep 16 2022 07:24:31 GMT-0400 (Eastern Daylight Time)

Please tell us about the problem

Instructions: Before filling out the form, please read the accompanying information that explains:
- Who you should contact for different types of pollution problems, and
- What happens when you contact the TCEQ.

Date observed: [   ]

Approximate time observed: [Select ∨]   AM/PM [Select ∨]

Address or location where the problem is occurring: [   ]

Nearest city or town: [   ]

County where the problem is occurring: [Select   ∨]

Who or what you believe is the source of the problem: [   ]

A brief description of the problem: (1,000 characters or less) [   ]

Please provide your contact information

The information requested below is optional. You do not have to tell us who you are or where you live. However, in some cases, not being able to contact you may limit our ability to investigate the problem. In addition, if we do not know who you are, we will not be able to contact you for follow-up information or advise you of results.

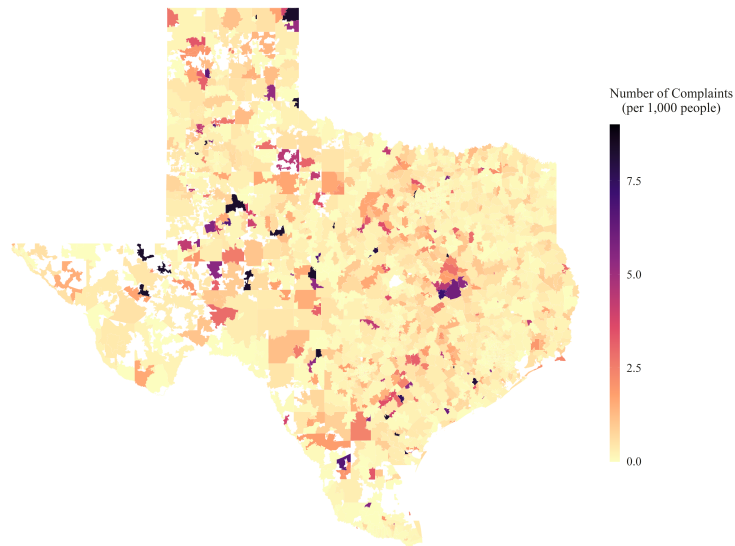Name: [   ]

Figure C3: Distribution of Number of Complaints Made per Incident
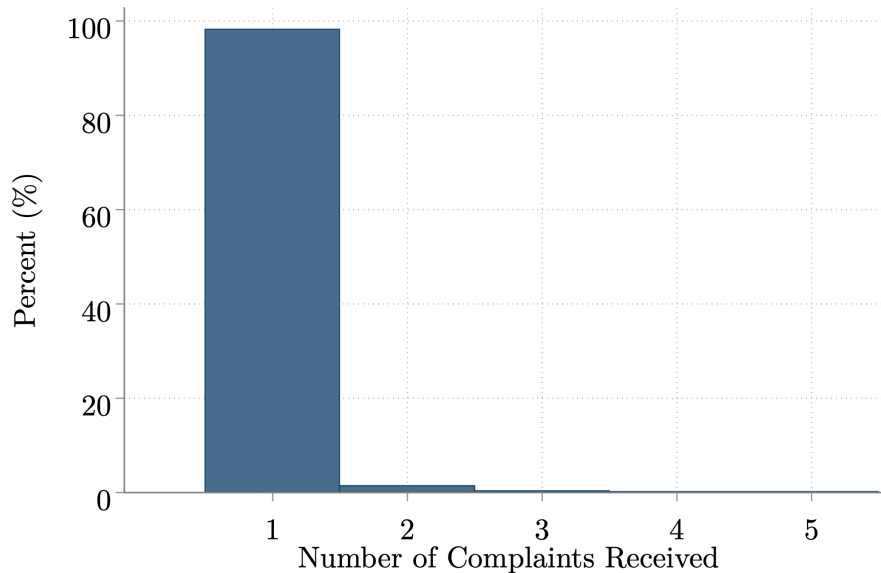
NOTES: Almost 98% of incidents are based on a single complaint. We trim the distribution above 16 complaints per incident (the 99th percentile) to aid visualization.

Figure C4: Number of Complaints (per 1,000 people)

NOTES: The number of complaints per 1,000 people variable is winsorized at the 99th percentile to aid visualization. The maximum number of complaints per 1,000 people is 52.

Figure C5: Distribution of Complaints by Type

- Water only
- Air only
- Waste only
- Type missing
- Multiple media
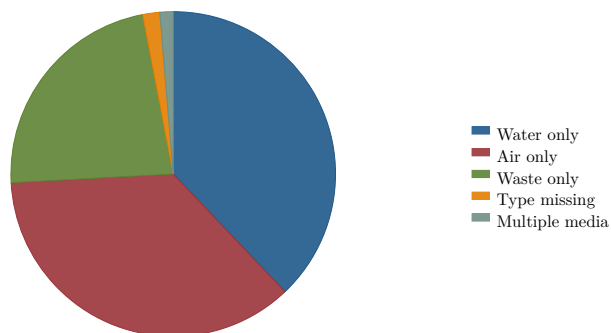
NOTES: Figure excludes complaints referred to another agency.

Figure C6: Characterizing Incidents

Incident Nature

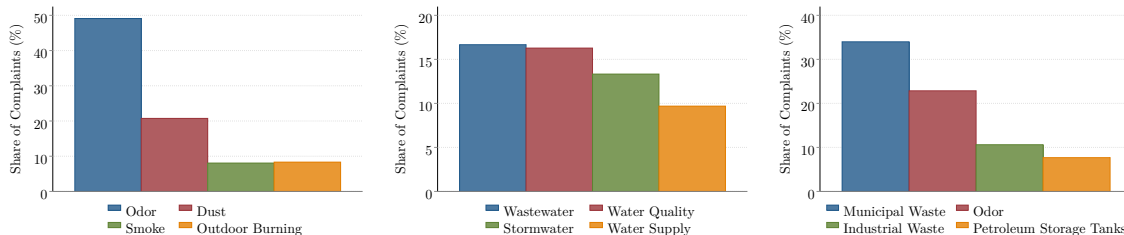Incident Concern
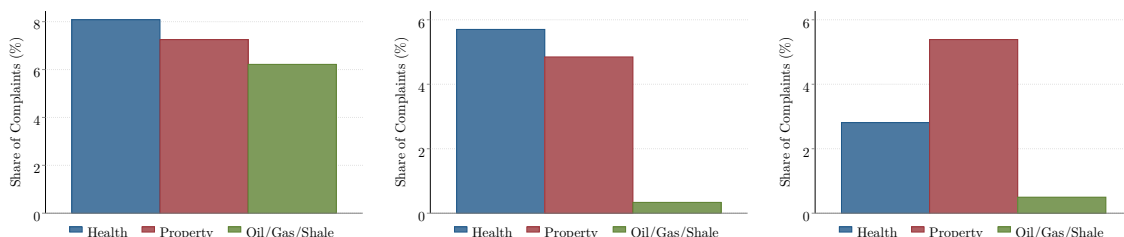
Word Clouds

(a) Air   (b) Water   (c) Waste

NOTES: This Figure documents the nature of complaint incidents by pollution medium, the concern of complaints by pollution medium, and word clouds of the most frequent terms by pollution medium. In the word clouds, the size of each term is approximately proportional to its probability. The color of each term in the word clouds is randomly assigned. Column a) figures relate to air complaints, column b) figures relate to water complaints, and column c) figures relate to waste complaints.

Figure C7: Incident Nature Over Time

(a) Air
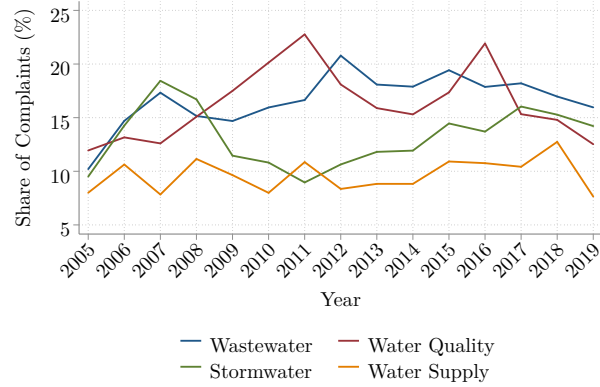
(b) Water

(c) Waste

NOTES: The figure documents the nature of complaint incidents by pollution medium over time.

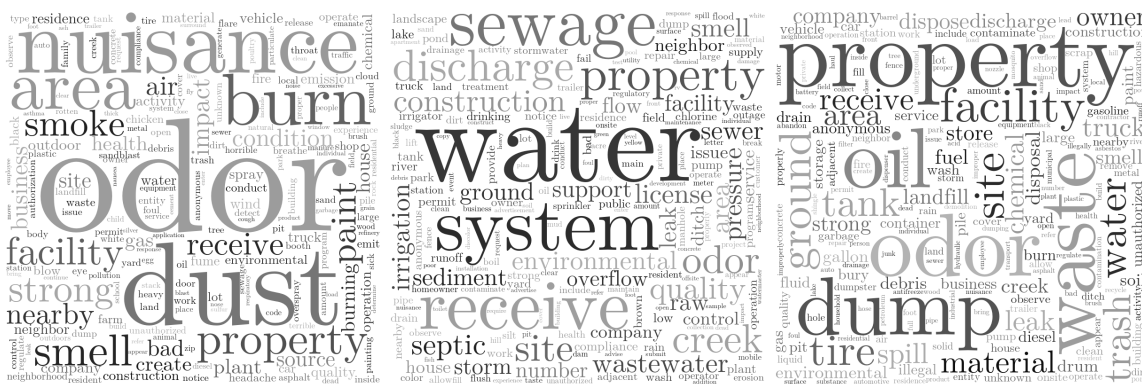Figure C8: Incident Concerns Over Time

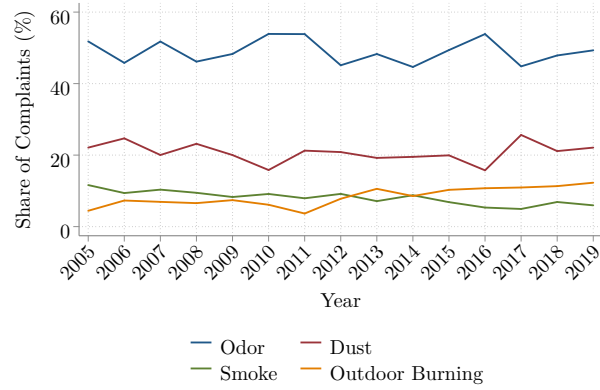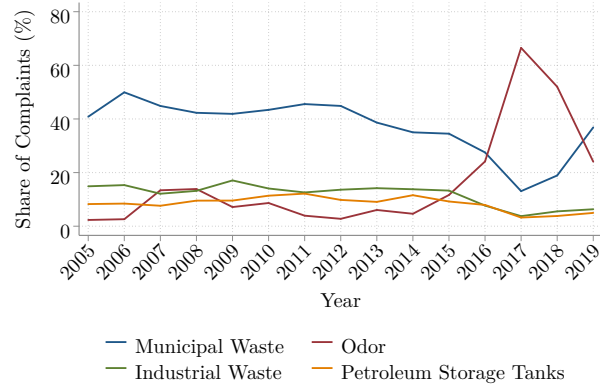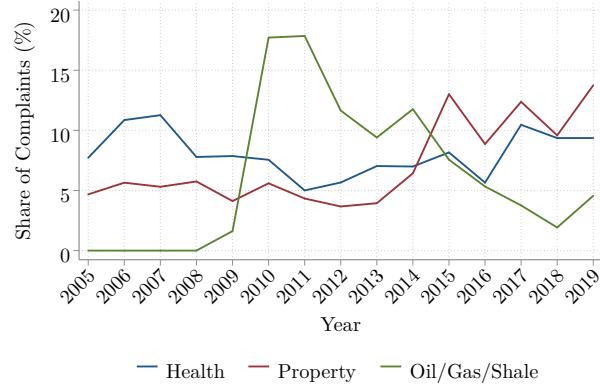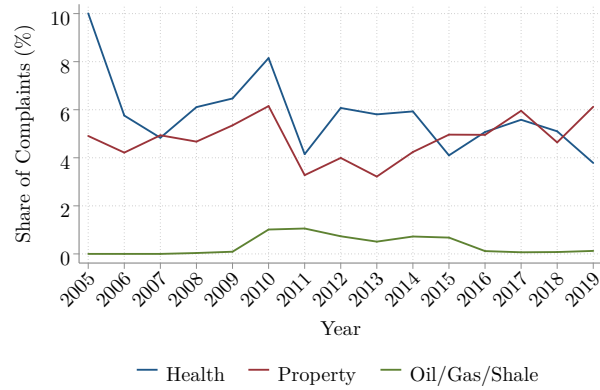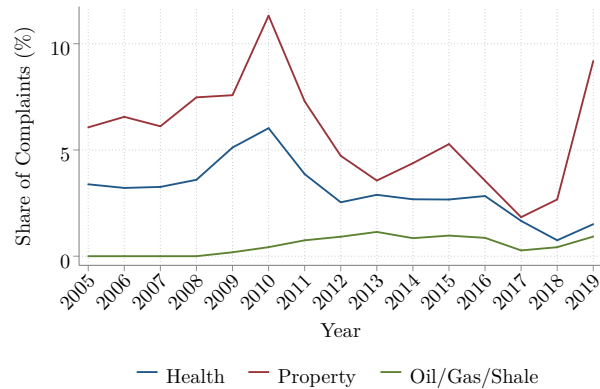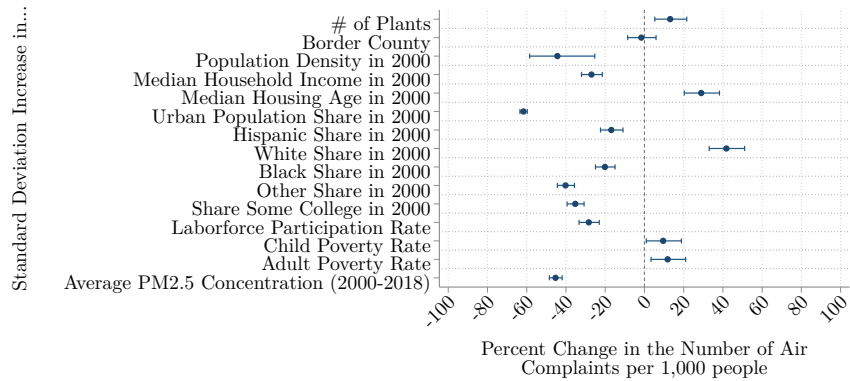(a) Air

(b) Water

(c) Waste

NOTES: The figure documents the nature of complaint incidents by pollution medium over time.

## C.1 The Socioeconomic Correlates of Citizen Complaints

Figure C9 presents cross-sectional socioeconomic correlates of per capita complaint incidents at the zip-code level. The three panels depict correlates for air, water, and waste complaints, respectively. The general patterns are consistent across media. Complaints per capita are negatively associated with population density and urban population share. A one standard deviation (s.d.) increase in baseline urban population share is associated with around a 60 percent reduction in the number of air, water, and waste complaints per capita. Complaints per capita are also negatively associated with zip-code level median household income, educational attainment, and labor force participation and positively associated with zip-code level median housing age and poverty indicators. A one s.d. increase in a zip code's baseline household income is associated with a 20 to 30 percent reduction in the number of air, water, and waste complaints per capita. Complaints are positively associated with the zip-code level share of the population identifying as non-Hispanic white and negatively associated with the zip-code level share of the population identifying as Hispanic, non-Hispanic Black, and other race/ethnicity groups. A one s.d. increase in baseline share of the population that is non-Hispanic Black or Hispanic is associated with a 20 to 30 percent reduction in the number of per capita complaints. Air complaints (Figure C9a) are negatively associated with average particulate matter concentrations. A one s.d. increase in zip-code level PM2.5 concentrations is associated with a 45 percent reduction in the number of per capita complaints. We also explore correlates after splitting the sample by rural/urban designations. In more rural areas, per capita complaints are more common in areas that are less wealthy and more Hispanic. In more urban areas, per capita complaints correlates with socio-economic factors are insignificant and small.

We caution against overinterpretation of descriptive associations between per capita complaints and average community characteristics. Bivariate cross-sectional relationships are not intended to be causal and do not reflect the characteristics of the specific individuals who file complaints. For example, the negative correlation between citizen complaints and the share of the population that is college educated doesn't imply that college educated individuals are less likely to make complaints, all else equal. Indeed, evidence from our individual-level survey suggests that more educated individuals are more likely to report filing a complaint.

Figure C9: The Socio-Demographic and Economic Predictors of Citizen Complaints

(a) Air
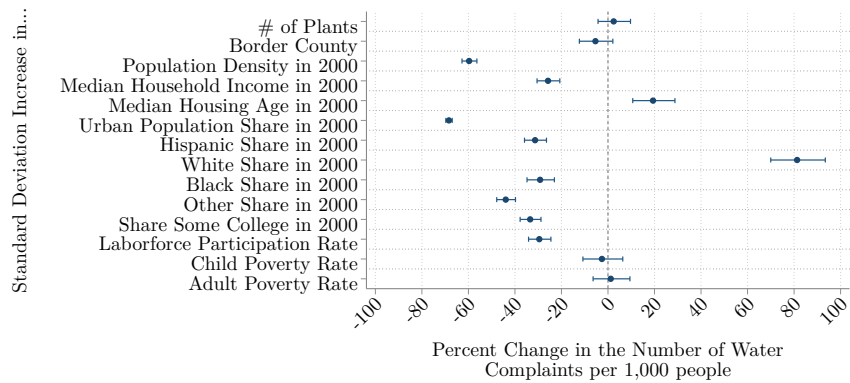
(b) Water
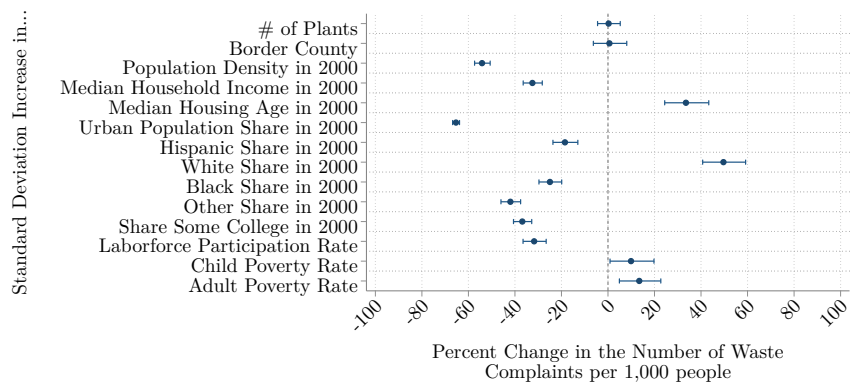
(c) Waste

NOTES: The unit of analysis is a zip code. Each estimate comes from a bivariate OLS regression between the log transformed number of citizen complaints per 1,000 people and a given local characteristic: $log(\text{complaints per 1,000 people}_z) = \alpha + \beta X_z + \varepsilon_z$. We transform each of the estimates and confidence intervals ($100 \times [\exp(\hat{\beta}) - 1]$) to provide a percent change interpretation.

C.2 Text Analysis of Complaint Descriptions

To provide a more nuanced picture of the content of environmental citizen complaints, we make sure of the text description each complaint. Figure C6 presents word clouds generated from the text of the complaint descriptions. The word clouds reflect similar points of emphasis as the administrative codes. Common lemmatized word stems in air complaint descriptions include "odor", "dust", "burn", "smoke", and "smell." Word stems in water complaint descriptions include "system", "sewage", "property", "wastewater", and "septic." Word stems in waste complaint descriptions include "property", "oil", "dump", "odor", and "trash."

We attempt to further characterize the full complaint descriptions using text analysis tools (Gentzkow et al., 2019; Ash and Hansen, 2022). We use a Latent Dirichlet Allocation (LDA) approach, a document classification method that uses machine learning to identify natural groupings (Blei et al., 2003; Hansen et al., 2018). A key advantage of the LDA approach is that it is unsupervised, i.e., it does not require researchers to prejudge important words and themes ex-ante.

Pre-Processing the Complaints Data

Before we are able to analyze the text in the TCEQ complaints data we must put it into a form that can be processed. We take three steps: 1) Tokenization breaks each complaint into units called tokens which can then be processed using text analysis models. We tokenize the data into words. These tokens form the vocabulary (set of unique tokens) across all complaints. 2) Once the data has been tokenized, we make every letter lowercase and remove special characters, numbers, and punctuation. We then remove "stop words". Stop words are words such as "the" and "a", which are common but do not add anything to the analysis. The python module `nltk` has a built in stop words list; we add additional custom words based on our context. For example, we added a list of common last names in Texas[32], Texas counties[33] and cities[34], honorifics, proper nouns, and other common words, such as complaint, allege, TCEQ, etc. 3) We normalize text by lemmatization. Lemmatization transforms words into a base form that is actually a word in the dictionary. For example, decide and decided might both be reduced to decide.

Having tokenized the data, removed stopwords, and normalized the text we follow Hansen et al., 2018). and rank the remaining tokens using term frequency-inverse document frequency (tf-idf), a measure of informativeness that punishes both rare and frequent words.

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[32]https://forebears.io/united-states/texas/surnames
[33]https://dshs.texas.gov/chs/info/info_txco.shtm
[34]https://www.texas-demographics.com/cities_by_population

We drop all tokens ranked 6,500 or below, providing 12,079 unique terms for all complaints, 5,131 unique terms for air complaints, 5,495 unique terms for waste complaints, and 7,136 unique terms for water complaints (Table C1).

Latent Dirichlet Allocation Approach

LDA is a Bayesian factor model for discrete data and works by trying to recreate the data using a multi-layered sampling approach. Consider the case in which there are D documents containing a corpus of text with V unique terms. Within these documents we want to identify topics. Each topic K is a probability vector $\boldsymbol{\beta}_k \in \Delta^{V-1}$ over the V unique terms in the data. A topic is a weighted list of words that express the same underlying theme.

Each document can belong to multiple topics, i.e., each document d has its own distribution over topics given by $\boldsymbol{\theta}_d$. θ_d^k represents the contribution of topic k to document d. The probability that any given word in a document d is equal to the vth term is, $p_{dv} \equiv \sum_k \beta_k^v \theta_d^k$ and the overall likelihood is, $\prod_d \prod_v p_{d,v}^{n_{d,v}}$ where $n_{d,v}$ is the number of times term v appears in document d.

Each θ_d is assigned a symmetric Dirichlet prior with K dimensions and hyperparameter α. Each β_k is assigned a symmetric Dirichlet prior with V dimensions and hyperparameter η. Following Griffiths and Steyvers (2004) and Hansen et al. (2018) we set $\alpha = 50/K$ and $\eta = 0.025$. The low value of η promotes sparse word distributions so that topics tend to feature fewer, more prominent, words.

The inference problem in LDA is to approximate the posterior distributions over $\boldsymbol{\beta}_k$ for every k and over $\boldsymbol{\theta}_d$ for every d given K, α, and η. We use Gibbs sampling, a popular Markov chain Monte Carlo algorithm, introduced by Griffiths and Steyvers (2004).[35] Following Hansen et al. (2018) we repeat this process 4,000 times as a burn in phase, and then further repeat the process 4,000 times more storing the output from every 50th sample. We examine the perplexity of the stored samples to explore whether the Markov Chain has converged. Perplexity measures how well the model fits the data (i.e. how well the assignments and weights can generate the document). A lower perplexity indicates a better fit. If the perplexity is stable, one can be reasonably confident that the chain has converged.We see that there is stability in the perplexity score after 5,000 iterations and that the scores are similar across chains, indicating that the starting seed doesn't have a meaningful effect on the final outcome.

LDA substantially reduces the dimensionality of the data; however, choosing the number of topics, for a given context is a challenge. There is a trade-off between how interpretable

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[35]See the technical appendix produced by Hansen et al. (2018) for more details on the Dirichlet distribution, LDA, and derivations of the Gibbs Sampling equation.

the model's output is, favoring smaller values of K and how well the model fits the data, favoring higher values of K (Chang et al., 2009). We chose K = 10 for our main analysis but have explored robustness to alternative choices. Fewer topics were too general and a larger number of topics became too specific to individual complaints.

Output

The main LDA output that we are interested in is the topics themselves. Each topic is a probability vector over the 5,277 unique tokens in the corpus that remain after we have processed the text data. Figure C10, C11, and C12 present wordclouds for 10 topics within air, waste, and water complaints respectively. Although there is nothing about the LDA estimation strategy that guarantees topics with a clear interpretation, we found it relatively straightforward to label the output. We caveat that our topic interpretations are subjective, but note that this has limited consequence because the labels play no role in any formal analysis.

For air complaints, the LDA text analysis highlighted a topic cluster related to health concerns, where lemmatized word stems included "cough", "headache", "eye" (irritation), "breathe", "house", and "sick" (Figure C10). Five topic clusters related to industrial sector: auto body shops, agriculture, construction, oil and gas, and general business. Three topic clusters related (again) to odor, smoke, and burning. One topic related to administrative features of complaint administration. For waste complaints, the LDA text analysis generated five topic clusters related to the nature of the waste including industrial waste, municipal waste, fuel spills and leaks, water contamination, and tire waste and burning (Figure C11). One topic cluster related to odors from waste and one related to disposal method. One topic cluster related to auto body shops, one appears to relate to waste dumping, and one related to administrative features of complaint administration. For water complaints, the LDA text analysis uncovered one topic cluster related to drinking water quality, where lemmatized word stems included "odor", "color", "brown", "boil", and "dirty" (Figure C12). One topic cluster related to water pressure quality. Four topic clusters related to sources including industrial leaks, agricultural water use, sewage / septic, and stormwater. The remaining topics were related to the nature of receiving waters.

Table C1: The Number of Terms in the Air Complaints Data at the Different Processing Stages

	RAW TEXT	TOKEN CLEAN	REMOVE STOPWORDS	LEMMATIZATION	TF-IDF
All Complaints:					
Total Words	3994750	3865489	1556843	1556843	1262573
Unique Words	49116	49060	47252	43549	12079
Air Complaints:					
Total Words	1,182,855	1,146,465	463,549	463,549	349,848
Unique Words	22,364	22,320	20,704	18,466	5,131
Waste Complaints:					
Total Words	1012192	982878	404641	404641	322950
Unique Words	24176	24129	22467	20135	5495
Water Complaints:					
Total Words	1718934	1657939	657473	657473	513158
Unique Words	28697	28649	26929	24346	7136

NOTES: This table reports the number of terms at each stage of text processing, starting from the raw text through to imposing the term frequency-inverse document frequency (tf-idf) restriction. Panel A reports counts for all complaints. Panel b reports counts for the air complaints sample. Panel c reports counts for the waste complaints sample. Panel d reports counts for the water complaints sample.

Figure C10: Topic-Specific Wordclouds (Air Complaints)

(a) Odor (b) Gas & Oil (c) Auto/Body Shop (d) Administration (e) Business

(f) Smoke (g) Agriculture (h) Construction (i) Health Concerns (j) Burning

NOTES: This Figure presents word clouds for each of our estimated 10 topics using the LDA model. In the word clouds the size of each term is approximately proportional to its probability. The color of each term in the word clouds is randomly assigned.

Figure C11: Topic-Specific Wordclouds (Waste Complaints)

(a) Administration   (b) Fuel Spills/Leakage   (c) Odor   (d) Industrial Waste   (e) Municipal Waste

(f) Auto/Body Shop   (g) Dumping   (h) Water Contamination   (i) Disposal Method   (j) Tires

NOTES: This Figure presents word clouds for each of our estimated 10 topics using the LDA model. In the word clouds the size of each term is approximately proportional to its probability. The color of each term in the word clouds is randomly assigned.

Figure C12: Topic-Specific Wordclouds (Water Complaints)

(a) Septic Tanks

(b) Waste Water

(c) Construction Runoff

(d) Receiving Waters

(e) Dumping

(f) Stormwater/Weather Overflow

(g) Residential Issues

(h) Agricultural Water

(i) Odor

(j) Recreational Water Concerns

NOTES: This Figure presents word clouds for each of our estimated 10 topics using the LDA model. In the word clouds the size of each term is approximately proportional to its probability. The color of each term in the word clouds is randomly assigned.