Excess emissions: Environmental impacts, health effects, and policy debate

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Abstract

Air pollution releases due to accidents, malfunctions or unanticipated facility start-ups and shutdowns are classified as excess emissions by the Environmental Protection Agency. Excess emissions are violations of the Clean Air Act. Despite this, states have historically granted emitting facilities exemptions, shielding them from enforcement and penalties. Since 2015 there has been a considerable debate regarding these regulatory provisions and about excess emissions policy more generally. We outline recent research that documents the incidence, magnitude, environmental impacts, and health effects of these emissions. This work highlights the damages caused by excess emissions and is therefore relevant and informative to the policy debate surrounding their regulation. Moreover, the majority of prior research focuses on Texas because it is the only state that provides access to detailed data on excess emissions that can be easily used for research. This data limitation creates uncertainties about the incidence, magnitude, and impacts of these emissions outside of Texas. We argue that a requirement for detailed data reporting in all states would best enable policy makers to design an effective regulatory framework.

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1 Introduction

On March 17, 2019, a fire ignited in a chemical storage tank at the Intercontinental Terminals Company (ITC) in Houston, Texas. Within hours, the fire spread to six adjacent gasoline and chemical storage tanks and over the course of the next three days the fire released more than 7,500 tons of carcinogenic and toxic substances into the air. The incident garnered widespread national media coverage in part because it created a large and opaque plume of smoke that blanketed downtown Houston (Figure 1). Federal and state environmental officials monitoring the nearby area found large increases in the concentrations of dangerous pollutants (Figure 2) and issued a "shelter-in-place" order for nearby citizens due to elevated benzene concentrations (WBUR, 2019; TCEQ, 2019).[1]

Accidents like the ITC fire, as well as polluting events due to malfunctions or unanticipated facility start-ups and shutdowns, are classified as excess emissions events by the EPA (EPA, 2015). Excess emissions are different than routine emissions released during "steady state" (i.e., regular) operations of a facility (TCEQ, 2005).[2] While the ITC fire was a major industrial accident, this type of event is not uncommon (Figure 2c). In Texas alone, there are over 3,400 excess emissions events per year. Excess emissions release substantial amounts of pollutants that are, at times, comparable to a facility's routine emissions. Occasionally a single event can exceed the annual routine emissions for a facility (Parrish et al., 2009; Zirogiannis et al., 2018).[3] However, despite their frequency and magnitude, excess emissions events rarely receive the national media attention that the ITC fire attracted.

While excess emissions events are common and have been shown to adversely affect air quality and nearby health, environmental economists and policy makers have paid little attention to their incidence and damages within the US relative to other sources of air pollution. This is in part because, with the exception of Texas, almost no other state keeps detailed records of excess emissions in a systematic way that can be used for research. Moreover, between 2017-2020 the EPA relaxed the regulatory standards governing excess emissions, without considering the health and environmental damages they cause.

The goal of this article is to communicate recent research results that document the prevalence, distribution, and health damages of excess emissions in a manner that is informative for policy and that highlights the uncertain welfare effects imposed by recent deregulatory

[1]Figures 2a and 2b shows concentrations of pollutants at two monitors located 3.2 kilometers and 7.7 kilometers away, before and after the ITC fire. Approximate monitor locations are noted on Figure 1.

[2]Routine emissions for facilities are approved via permits issued by state and local agencies, while excess emissions are pollution releases above these thresholds.

[3]Alvarez et al. (2018) find that emissions estimates underestimate actual methane released from the oil and natural gas supply chain by 60% because current estimates do not account for methane releases during non-routine operations (e.g., during malfunctions).

efforts. We note that more could be learned about excess emissions if all states were required to keep systematic record of excess emissions and make them available to the public in a timely fashion. We proceed by discussing the regulatory background on excess emissions, summarize the literature on the environmental and health damages, and conclude with a policy summary and suggestions for future work.

2 Regulatory Background

Excess emissions are releases of air pollution above the applicable facility permit limits set as part of State Implementation Plans (SIP) that occur during startup, shutdown, malfunction or other modes of operation (EPA, 2015).[4] Excess emissions constitute violations of the Clean Air Act (CAA), yet states have regularly granted emitting facilities exemptions that shield the facilities from enforcement and penalties.[5]

In 2015, prompted by a lawsuit spearheaded by the Sierra Club, the EPA released a SIP call requiring 36 states to revise their regulatory frameworks for excess emissions. With that decision, the EPA found that these states had provisions in their SIPs regarding excess emissions that were "*substantially inadequate*" to meet CAA requirements (EPA, 2015). Soon after it was finalized, the 2015 SIP call was challenged in court by a group of states and industry representatives. In 2017, the EPA placed the SIP call on hold and asked the D.C. Circuit court to cancel oral arguments for the case. More recently, in October 2020, the EPA reversed course and released a guidance memorandum that, once again, allowed various enforcement exemptions of excess emissions events in SIPs (EPA, 2020).

These deregulatory efforts do not consider the full welfare impacts of excess emissions and can be questioned on several grounds. Little is known at the national level about the frequency and magnitude of excess emissions. Just a few states keep systematic records about them and make information publicly available in a meaningful and comprehensive way. With such limited information, it is difficult to craft effective policy on this complex, operational aspect of industrial activities. The state of Texas stands alone in its comprehensive disclosure and record-keeping requirements. Facilities in Texas are required to report excess emissions events within 24 hours, and the information that the facility provides to the Texas Commission on Environmental Quality (TCEQ) becomes immediately available to the public through the agency's website. Thus the majority of prior research in this area is limited to studying incidence and damages within this one state.

[4]A State Implementation Plan is a collection of regulations used by a state, territory, or local air district to implement, maintain, and enforce the National Ambient Air Quality Standards, and to fulfill other requirements of the Clean Air Act (EPA, 2021a).

[5]Examples include automatic exemptions and affirmative defense (EPA, 2015, pg, 33842).

3 Environmental and health impacts of excess emissions

Several papers in the atmospheric science discipline have studied excess emissions mainly through the use of atmospheric plume modeling and find that excess emissions have the potential to substantially affect air quality (Choi et al., 2006; Kulkarni et al., 2007; Vizuete et al., 2008). Our own work has focused on incidence (Zirogiannis et al., 2018), distribution (Li et al., 2019), pollution impacts, and health consequences (Hollingsworth et al., 2021) of these events. Below, we outline what is currently known about these emissions and their effects from these recent studies.

Using just data from Texas, Zirogiannis et al. (2018) show that excess emissions occur on a regular basis and their magnitude is often comparable to that of routine emissions. From 2004 to 2015, excess emissions of VOCs from industrial sources in Texas represented 7.5% of routine emissions from the same facilities. For individual pollutants, the share of excess vs. routine emissions can be substantially higher (e.g., 13.4% for isobutane, 16.1% for butane, 16.3% for butene, and 19.7% for propylene). From 2004 to 2007, there were, on average, $3,400$ excess emissions events annually in Texas. While the majority of those events emit less then 1 ton of a pollutant, large events are quite frequent. Across excess emissions of all pollutants, on an average day in Texas, there is at least one event that releases over 10 tons of pollution; in an average month, there are three events that each release over 100 tons; and in the average year, there are at least three events that each release over 1,000 tons (Hollingsworth et al., 2021). In addition, excess emissions tend to occur near census blocks with higher proportions of Black residents (Li et al., 2019).

Given how skewed the distribution of excess emissions is, it is important to acknowledge that some emitters have an oversized impact on total amounts released. In fact, in any given year roughly 56% of firms reporting to the state emissions inventory have zero excess emissions. To better understand if some facilities consistently release high amounts of excess emissions, we conduct a simple analysis that compares how the percentile of each firm with respect to the ratio of excess emissions to routine emissions, changes across time.

For each firm, we calculate their excess to routine percentile against all other firms in two consecutive time periods. We then construct a binned scatterplot that demonstrates how the percentile in the first time period (2006 to 2012) relates to the percentile in the second time period (2013 to 2019). Importantly, we restrict this analysis to a balanced panel of firms across time to avoid issues created by facilities that either exit or enter across time.

Figure 3 displays results from this analysis. Each point shows the average percentile in the second time period (2013 to 2019) plotted against the ventile of the first time period (2006 to

2012). For example, the top right bullet on the Figure suggests that facilities that were above the 95th percentile in 2006 to 2012, were—on average—in the 81st percentile in 2013 to 2019. The relationship is roughly linear, indicating that the ratio of excess emissions to routine emissions is a relatively stable for each facility across time. This analysis suggests that excess emissions are not entirely random events, equally likely to occur at every industrial facility, but rather that there is a systematic correlation in the probability of their occurrence across time.

Hollingsworth et al. (2021) directly link the size of excess emissions events to increased pollution and nearby elderly mortality. This work shows that excess emissions of VOCs, CO and NO_x lead to increases in ambient ozone concentrations, which increase elderly mortality in Texas. Specifically, a 10% increase in monthly average ozone induced by excess emissions, increases elderly mortality by 3.9%.

We display estimates of the monetary value of these damages in Figure 4. Panel A displays estimates of monetized mortality damages using Air Pollution Emission Experiments and Policy version 3 (AP3) (Clay et al., 2019; Tschofen et al., 2019), which considers how excess emissions lead to premature mortality across all ages, rather than just the elderly. This model links emissions to downwind changes in pollution concentrations and associated changes in health, monetized using the value of a statistical life. Results from using this integrated assessment model suggest that total annual damages from pre-mature morality in Texas exceed $300 million annually. The black dashed line in panel B displays the elderly mortality damage estimates from (Hollingsworth et al., 2021), which are between $13.6-$23.8 million annually. The grey solid line in panel B displays an adjusted AP3 estimate that is more comparable to the elderly-mortality damage estimates (see Hollingsworth et al. (2021) for more details).

4 Lack of state level data on excess emissions

Prior research is generally limited to the state of Texas because it is the only state in the country with extensive reporting and record-keeping rules for excess emissions events. There, following a Public Information Request to the TCEQ one can obtain detailed information about each excess emission event (including day and duration of occurrence, amounts of pollutants released, geographic coordinates of the release, etc.). Outside Texas, data available on excess emissions vary substantially and in general are not suitable for research (Zirogiannis et al., 2018).

In the absence of detailed record-keeping requirements, it is not possible to estimate the incidence and health impacts excess emissions have in states around the country. An important priority for state environmental agencies and the EPA should be to develop the type of comprehensive and publicly available record keeping and reporting system that the TCEQ has in place. Better information about the incidence of excess emissions will enable the design of an effective regulatory framework.

5 Recent deregulatory efforts

The enforcement framework surrounding excess emissions has been in flux since 2015. In an October 2020 guidance memorandum, the EPA outlined a series of arguments based on which it would, once again, be permissible for states to include the types of enforcement exemptions that the 2015 SIP Call found to be in violation of the Clean Air Act.

In that memorandum, the agency argued that states which meet the National Ambient Air Quality Standards (NAAQS) should be allowed to exempt excess emissions events to avoid compromising "state autonomy and flexibility" (EPA, 2020). Second the EPA asserted that excess emissions are often unavoidable. Therefore, removing regulatory exemptions would not help to reduce excess emissions since nothing can be done to mitigate the events. Below we illustrate how recent research on excess emissions provides more context to understanding the validity of each argument.

NAAQS compliant states should be able to grant exemptions: The reasoning supporting this argument raises four main concerns. First, achieving air quality levels in compliance with the NAAQS, does not eliminate health or environmental damages. The literature has decisively demonstrated important inaccuracies in ambient air quality monitoring related to strategic behavior on the part of polluters (Zou, 2021), discrepancies between readings of regulatory monitors and satellite data (Sullivan and Krupnick, 2018), or even the potential for strategic behavior to alter air quality readings on the part of regulatory agencies (Mu et al., 2021). Furthermore, the NAAQS pertain only to a short list of six criteria pollutants. There are thousands of toxic chemicals whose concentrations are not continuously monitored and that can cause adverse health impacts even due to short term exposure. The example of the ITC fire discussed earlier and the shelter-in-place order that was issued by state authorities points to this gap. Attainment with the NAAQS therefore does not guarantee safe ambient levels of air quality given the amount of strategic responses by facilities and state regulators, as well as due to gaps in air quality monitoring.

A second concern is that EPA's argument neglects the increasingly growing body of literature demonstrating that substantial health impacts can occur even at levels below the NAAQS (e.g. Lepeule et al., 2012; Di et al., 2017). Thus reducing excess emissions events, even in NAAQS attainment counties, would serve to decrease the risk of premature mortality and morbidity.

Third, this argument does not consider the transboundary nature of air pollution. Our own work has demonstrated that excess emissions of VOCs, CO, and NOx can increase ozone concentrations even 25 miles away from the source of the release, and possibly even further (Hollingsworth et al., 2021). Facilities located in a NAAQS compliant state can therefore affect air quality, and health in areas beyond their own jurisdictions. Even if a state containing the emitting facility has pollution levels in compliance with the NAAQS, the emissions could still be affecting NAAQS compliance, and health, in nearby states.

Finally, this logic does not consider the challenges in determining NAAQS compliance. In Texas, regulatory exemptions are granted as long as a specific event did not contribute to a NAAQS violation. However, demonstrating that a single excess emissions event caused a county to fall into NAAQS non-attainment is extremely challenging, in part due to the way non-attainment is defined. For example, attainment with the ozone NAAQS is based on the annual fourth highest maximum 8-hour concentration averaged over three years. Given that framework, it may be impossible to decisively determine whether a single excess emissions event led to an increase in ozone concentrations and contributed to a violation of the NAAQS.

Excess emissions are often unavoidable: This argument is predicated on the fact that facilities can receive protection from civil penalties (by claiming affirmative defense) if they can prove to the regulator that an excess emissions event was unavoidable and could not have been prevented in any way. This argument, however, is not grounded in empirical evidence since no studies (our work included) have examined the effect that enforcement has on the incidence of excess emissions.

Using information that facilities provide in reports describing each excess emissions event and explaining the cause, Zirogiannis et al. (2018) conduct a text analysis to identify similarities in stated contributing factors across all events. The analysis employed structural topic modeling (Roberts et al., 2016), which first determines topics present within the entire corpus of text by finding collections of words that often appear together and then uses these topics to classify each respective text entry. As a secondary check, Zirogiannis et al. (2018) also calculated the percent of event descriptions that contained words common to unavoidable weather events (e.g., lightning, hurricane). Results showed that only an approximate 10% of excess emissions events are attributable to *force majeure* weather events like thunderstorms, hurricanes, or floods that are likely unavoidable.

Moreover, this argument conflicts with a large body of literature demonstrating the deterrence effects of enforcement or enforcement leakage (Nadeau, 1997; Shimshack and

Ward, 2008; Gray and Shimshack, 2011; Konisky and Reenock, 2013; Shimshack, 2014; Evans et al., 2018). Work by Shimshack and Ward (2008) in particular has demonstrated that industrial faculties adjust their water effluent releases to remain below permitted levels, while continuing to account for the possibility of accidental discharges.

6 Conclusion

Recently the EPA announced that it is withdrawing the October 2020 memorandum and reinstating the 2015 SIP Call and the agency's policy on excess emissions (EPA, 2021b). In January 2022, the agency ordered 12 states to revise their SIPs and bring them in line with the 2015 SIP call (EPA, 2022). These are important developments that set the stage for future rule making that can carefully reconsider the regulatory framework around excess emissions. We view recent work on excess emissions as relevant and informative in the process, since it highlights the incidence, magnitude, environmental impacts and health effects of these releases.

However, estimating marginal damages is only one component of crafting efficient policy. Important work remains to be done in estimating the cost of reducing excess emissions. This is particularly challenging since the cost of abatement will go beyond conventional means of installing pollution control devices and adjusting output. In the case of excess emissions, abatement costs will likely include investments in backup power, personnel training, and accident prevention procedures.

That said, federal and state regulators need to carefully consider the existing evidence on the health costs of excess emissions. Without detailed information on the incidence and magnitude of these events in all states, the cumulative health effects of these emissions remain uncertain.

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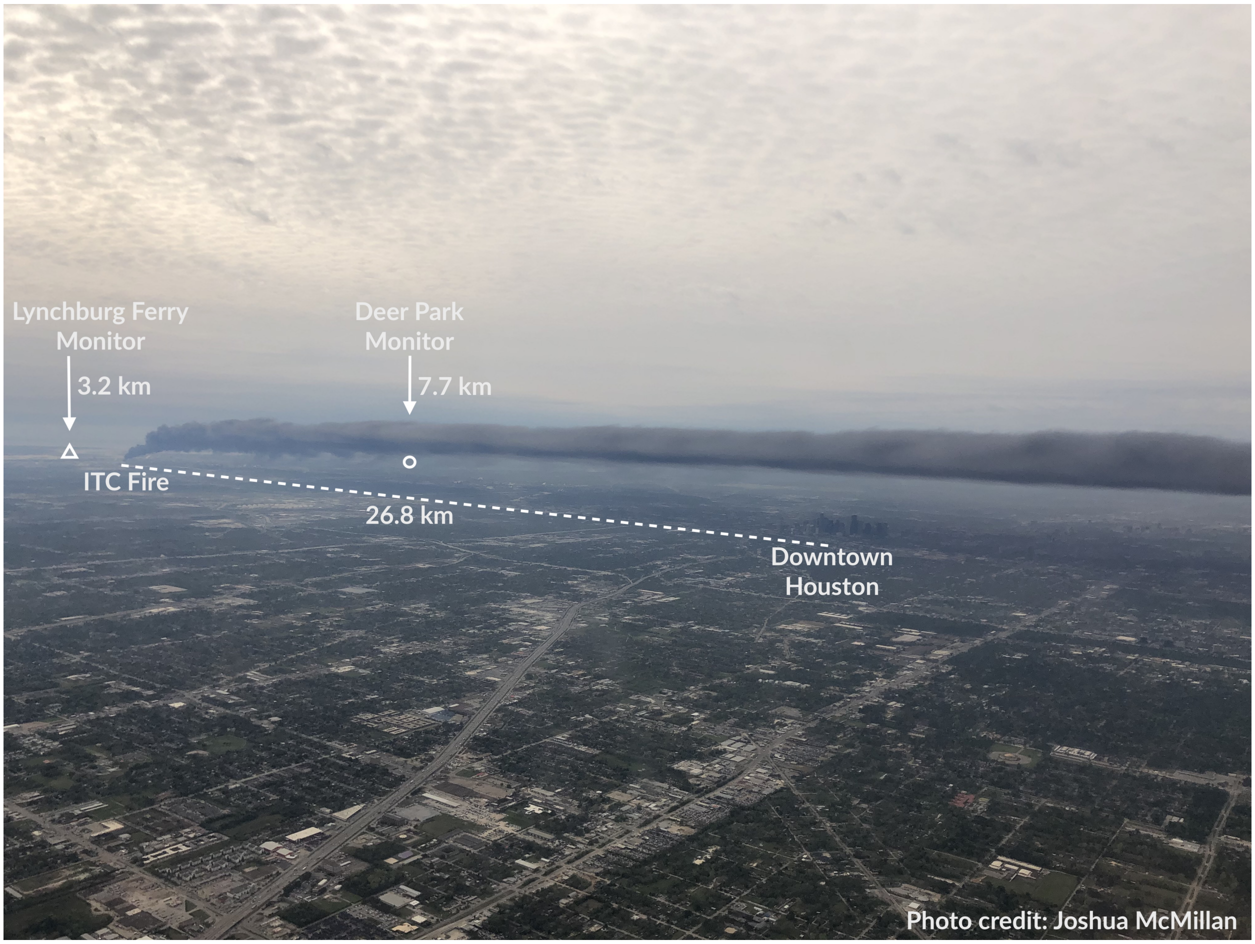
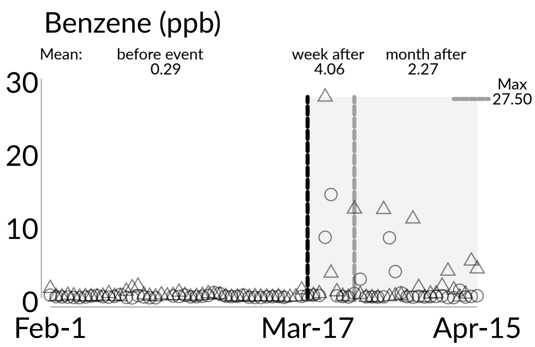
Figure 1: The ITC fire generated a large black smoke plume that covered downtown Houston



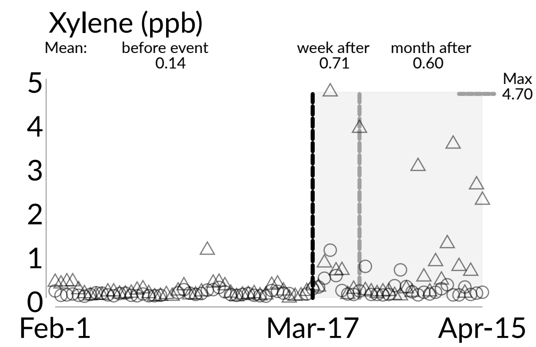
Note: The ITC fire generated a smoke plume that covered downtown Houston, 26.8 kilometers away. The triangle denotes the Lynchburg Ferry monitor, the circle denotes the Deer Park monitor; the two closest monitors to the facility. The marker shapes correspond to the locations of the pollution monitors whose daily pollution readings are displayed Figure 2.

Figure 2: The ITC fire increased Volatile Organic Compounds (VOC) levels nearby and is comparable to other large excess emissions events

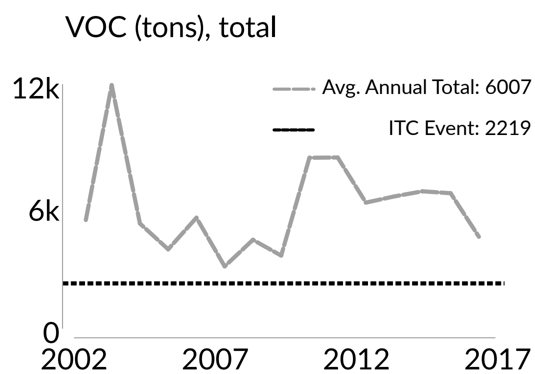
(a) Benzene concentrations



(b) Xylene concentrations

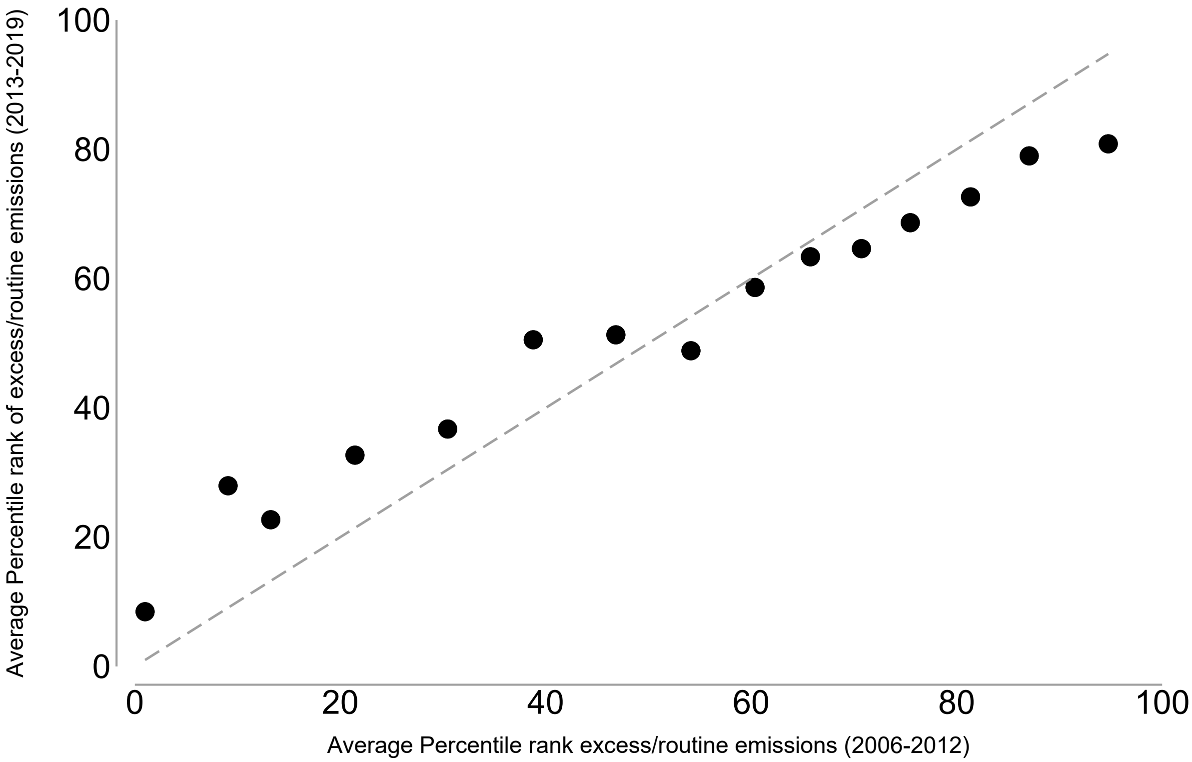


(c) Volatile Organic Compounds from ITC and all other excess emissions in Texas



Note: Panels (a) and (b) show how airborne concentrations of benzene and xylene changed after the ITC fire at the two closest monitors. Circles denote daily mean pollution readings from the Deer Park monitor located 7.7km southwest of the ITC Co. Triangles represent the average daily pollutant readings from the Lynchburg Ferry monitor 3.2 km north of the ITC Co. The black line denotes the day of the explosion and the grey line the week after the explosion. Figure 1 shows the location of each monitor from an aerial view. Panel (c) shows that these releases, while large, are not abnormal. The solid grey dashed line reports the total amount of VOC excess emissions releases in Texas during a given year. The black dotted line represents the amount emitted by the ITC fire event. All data come from TCEQ's Air Emissions and Maintenance Events dataset. Data on pollutants from the ITC fire are based on the final report the facility submitted to the TCEQ on July 18th 2019.

Figure 3: Binned scatterplot of persistent violators over time (Ratio of excess/routine emissions)

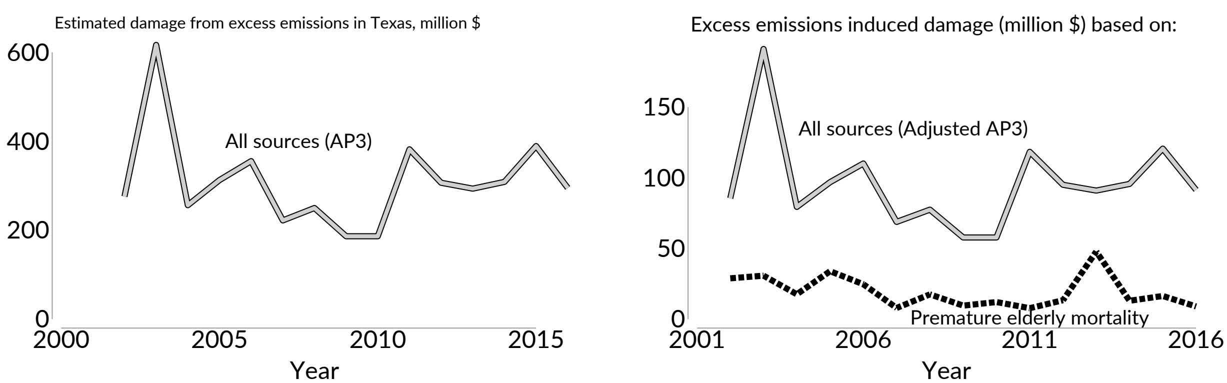


Note: Binned scatterplot illustrating the average facility rank by percentile of excess/routine emissions in the first half (2006-2012) vs. the second half (2013-2019) of the dataset (n=1,104 facilities). The dotted line (45 degree line) is illustrated for reference. Given the skewness of the distribution, there are multiple ties in the first 6 ventiles, which is why only 15 points are illustrated on the graph.

Figure 4: Damage estimates of excess emissions by year.

(a) Damages using Air Pollution Emission Experiments and Policy version 3

(b) Damage estimates adjusted for likelihood of premature mortality



Note: This figure is adapted from Hollingsworth et al. (2021) using the Air Pollution Emission Experiments and Policy version 3 (AP3) integrated assessment model rather than Air Pollution Emission Experiments and Policy version 2 (AP2). Damages are reported in 2021 \$. The solid grey line represents AP3 damages using 2014 as baseline year; in the left panel damage estimates are unadjusted and in the right panel damages are deflated by 31% to account for the fact that those likely to die from pollution are also more likely to die from other causes and thus are not counterfactually expected to live out their full life expectancy (Deryugina et al., 2019). See Hollingsworth et al. (2021) for more details. AP3 damage estimates account for mortality, morbidity, and other damages that occur as a result of pollution (Tschofen et al., 2019). The dashed black line represents damages from 65+ premature mortality from excess emissions as estimated in Hollingsworth et al. (2021).