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Dirty air, empty coffers? Nonprofit donations and volunteering in the context of severe air pollution

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Abstract

Purpose – Poor environmental conditions pose profound societal challenges, yet their impact on the nonprofit sector, particularly in terms of financial and organizational sustainability, remains largely unexplored. To address this concern, we investigate how hazardous air quality influences donations and volunteering in nonprofit organizations.

Design/methodology/approach – Combining county-level US EPA air quality data with 1.63 million IRS Form 990 filings by 248,749 nonprofits between 2010 and 2022, we examine the impact of air pollution on organizations across time and space. Instrumental variables regression and entropy-balancing techniques are employed to address potential endogeneity concerns. Additional analyses examine the roles of industry sub-sector, service orientation, donor sophistication and government funding in conditioning the relationship between air pollution and our two outcome variables.

Findings – Organizations in areas experiencing more hazardous air quality days are associated with lower levels of donations but higher levels of volunteering. Additional cross-sectional analyses suggest that environmental, health and human service nonprofits experience increased donations in the context of severe air pollution while arts and mutual benefit organizations see increased volunteering. Additional analyses on the conditioning effects of donor sophistication, service orientation, and government funding provide further insights into the empirical relationship between air pollution and nonprofit engagement.

Originality/value – This study provides one of the first large-N examinations of the organizational impact of localized environmental factors on charitable activity. In providing evidence for how air quality appears to be a robust, but underexplored factor affecting donor and volunteer behavior, our study underscores the importance of understanding how environmental challenges influence civic engagement.

Keywords Air pollution, Donations, Nonprofit organizations, Volunteering

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1. Introduction

In the summer of 2023, vast regions of Canada and the northern United States grappled with an unprecedented air quality crisis. Massive wildfires raging across Canada blanketed large parts of both countries in thick, hazardous smoke, forcing millions of residents to contend with

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deteriorating visibility, health advisories, and toxic air. This alarming event brought to the forefront the severe and far-reaching consequences of air pollution to many American communities in the Midwest and East for the first time in a generation. While such acute episodes capture public attention, they represent only one dimension of a broader and more enduring environmental challenge. Many regions across North America and, indeed, around the globe, regularly endure the effects of more chronic, persistent air pollution, with serious implications for these communities' public health and social and economic well-being. In the Global South, for instance, air pollution has become a pervasive, daily reality – an often-overlooked crisis aptly referred to as a "silent crisis" (Zavan, 2024). As wildfires, dust storms, and extreme temperatures continue to surge, the need to address the escalating impacts of poor air quality is urgent.

The mounting threat of air pollution and other climate-related disasters poses profound challenges across various sectors, yet its impact on the nonprofit sector remains largely unexplored. Existing nonprofit research has focused on voluntary action on climate change through policy advocacy, advocacy for behavioral change, participation in environmental governance, and direct intervention (see Kagan and Dodge, 2023 for a recent review of the literature). This line of research emphasizes the agency of nonprofit sector actors in responding to the climate crisis, but little to no archival work has been done on the consequences of climate change for the capacity and sustainability of nonprofits themselves. As climate-related stressors such as chronic air pollution become more frequent and severe, they can impact the work of nonprofit organizations through both demand-pull and supply-push mechanisms. On the *demand* side, the severity and urgency of air pollution motivates climate-focused nonprofits to take immediate action; air pollution also disproportionately affects socioeconomically disadvantaged populations and communities (Brochu *et al.*, 2011; Rentschler and Leonova, 2023), heightening the need for nonprofit-provided health care and human services. On the *supply* side, air pollution can impact the interest and ability of the community to engage with and support the work of nonprofit organizations, both by undermining physical health (Manisalidis *et al.*, 2020) and by influencing people's willingness to support charitable causes (Ming *et al.*, 2022). Taken together, these demand-pull and supply-push pressures place the capacity of nonprofit organizations – which rely heavily on donations and volunteer work – at increasing risk. Understanding how air pollution influences charitable behavior is crucial for developing strategies that ensure the resilience and sustainability of nonprofit entities. This issue is especially pertinent as nonprofits play a vital role in addressing the societal impacts of climate change.

This study aims to fill this gap in the literature by addressing this central question: What is the impact of air pollution on donations and volunteering to nonprofit organizations? Following an emerging body of literature that looks at how disasters or crises (Erlandsson *et al.*, 2022; Schwirplies, 2023; Steinberg and Rooney, 2005; Zagefka *et al.*, 2011) and other environmental factors (Mainardes *et al.*, 2017; Saxton *et al.*, 2024) affect charitable behavior, we posit here that higher levels of air pollution will depress monetary forms of charitable giving but elevate non-monetary forms of giving (that is, volunteering). To empirically examine these relationships, we employ IRS Form 990 data for 1.63 million U.S. nonprofit organizations and merge them with county-level air quality data from the US Environmental Protection Agency (EPA) from 2010–2022. To our knowledge, this is the first time these data have been employed together in the study of nonprofit organization engagement. We find that poor air quality, measured by the number of days classified as "hazardous" (AQI above 301) in the EPA's Air Quality Index (AQI), significantly influences donation and volunteering levels to nonprofit organizations. Specifically, nonprofits in counties experiencing severe air pollution – those with more "hazardous" days – tend to see decreased donations yet increased volunteering. These findings are supported by a variety of robustness tests, including instrumental variables and entropy balancing, to address potential endogeneity issues that could bias our multivariate estimates. Further analyses examine the roles of industry sub-sector, service orientation, donor sophistication, and government funding in conditioning the relationship between air pollution and our two outcome variables.

This study makes several contributions to the nonprofit accounting and financial management literature. To start, we are among the first to establish, both theoretically and empirically, the link between air pollution and nonprofit sustainability. As discussed earlier, air pollution can impact the work of nonprofit organizations through both demand-pull and supply-push mechanisms. Focusing on the supply side, we examine the impacts of air pollution on donating and volunteering in local nonprofits. In so doing, we seek to highlight how environmental threats can influence civic participation and financial support for nonprofit organizations – an area that to date has received limited attention in the literature. Our findings provide nonprofit organizations with insights into how climate change may be shaping donor and volunteer behavior, encouraging them to develop targeted strategies to maintain financial and operational resilience during periods of environmental upheaval.

In addition, this study extends the well-established economic model of giving initially developed by Weisbrod and Dominguez (1986) and subsequently refined by others (e.g. Calabrese and Grizzle, 2012; Harris *et al*., 2015; Jacobs and Marudas, 2009; Kaden *et al*., 2022; Quosigk and Forgione, 2018; Saxton *et al*., 2014). Specifically, in addition to the familiar determinants of giving such as the price of donations, the level of fundraising, the age of the organization, and the strength of organizational governance, our study introduces a novel environmental factor: air quality. We find that poor air quality has a dampening effect on the average level of monetary contributions received by nonprofit organizations. At the same time, we find nonprofits located in areas of poor air quality see an increase in volunteerism, highlighting enhanced non-monetary community engagement.

Collectively, the findings have practical implications for nonprofit financial management practices, suggesting new strategies for donor and volunteer retention and engagement. For instance, nonprofits may need to develop targeted communication and engagement strategies to address decreased donations in high-air-pollution areas. Additionally, the results could inform policy recommendations for nonprofit managers to enhance financial planning and risk management practices. Understanding how air pollution affects donations and volunteering can help nonprofit organizations better prepare for and mitigate the impacts of climate-related events. Ultimately, understanding the impact of air pollution on civic engagement is crucial for nonprofit managers and policymakers, as these organizations play a vital role in addressing pressing community needs (Guo and Brown, 2006). As highlighted in our study, air pollution can disrupt donor behavior and potentially jeopardize the financial stability of nonprofits, making it imperative to study how these risks influence charitable giving. Overall, our study underscores that air pollution can shape donor and volunteer behavior in ways that affect both community resilience and nonprofit sustainability.

The remainder of this paper is structured as follows: The next section provides a comprehensive review of the relevant literature, highlighting existing theories and empirical findings related to air pollution and philanthropic behavior. This is followed by the methods section where we describe our data sources, research design, and analysis plan. In the results section we then present our empirical findings and analysis. Finally, the conclusion summarizes the study's contributions, implications for practice, and suggestions for future research.

2. Theory and hypothesis development

2.1 Background on air quality and nonprofit organizations

With an astonishing 99% of the world's population living in a country where ambient air pollution levels fall short of World Health Organization guidelines (World Health Organization, 2022), air quality has become one of our time's increasingly salient issues. Air pollution can stem from acute "shock" events such as heatwaves (Shaposhnikov *et al*., 2014) and wildfires (Liu *et al*., 2016) that are sporadic or cyclical in nature, or from chronic sources such as industrial air emissions (Jaramillo and Muller, 2016). For example, wildfires are acute short-term events that impact air quality particularly during dry seasons, whereas industry-related air pollution (e.g. emissions from electric power generation, oil and gas extraction, coal mining, and oil refineries, etc.) have persistent impacts on air quality over an extended period. Regardless of its sources, the negative impacts of air pollution on human health are well documented (see Manisalidis *et al*., 2020 for a recent review).

Air pollution disproportionately impacts socioeconomically disadvantaged populations and communities. For example, Brochu *et al*. (2011) find that socioeconomically disadvantaged populations were exposed to higher ambient particulate matter (PM) air pollution in the Northeastern United States than their counterparts in the same region. In a more recent study of the relationship between ambient air pollution exposure and poverty in 211 countries and territories, Rentschler and Leonova (2023) find that 7.3 billion people, 80% of whom live in low- and middle-income countries, are directly exposed to unsafe average annual PM2.5 (particulate matter with a diameter of 2.5 micrometers or smaller) concentrations; and that 716 million of the world's lowest income people live in areas with unsafe levels of air pollution, especially in Sub-Saharan Africa.

These disparities in exposure also intersect with how communities respond behaviorally to different types of environmental stress. The distinction between chronic and shock air pollution is important not only for understanding health impacts but also for anticipating how communities and donors might respond differently to these environmental challenges. Drawing from the disaster literature (Brown and Minty, 2008; Kawawaki, 2023; Schwirplies, 2023; Steinberg and Rooney, 2005), we would expect donations to show different elasticity patterns in these two contexts. In areas with chronic air quality issues, donors may become desensitized over time, leading to less elastic and more stable giving patterns as communities adapt to persistent environmental challenges. In contrast, short-term shocks such as wildfires often trigger rapid but temporary surges in giving, followed by a reversion to baseline.

There are also urban and rural differences in air pollution, though the findings are not consistent across countries and regions. Strosnider *et al*. (2017) find that rural counties experienced fewer unhealthy air-quality days than large central metropolitan counties, likely due to the existence of fewer air pollution sources. Similarly, in a study of the impact of NO_2 (nitrous dioxide) on residents' life expectancy in Copenhagen, Denmark, Brønnum-Hansen *et al*. (2018) find that urban residents had lower life expectancy than rural residents due to higher NO_2 pollution. By contrast, in a comparative study of air pollution in urban and rural areas in China, Zhao *et al*. (2021) find higher risks of air pollution-related mortality among rural residents vis-à-vis urban residents.

While most of the existing literature on the negative impacts of air pollution is understandably focused on human health, poor air quality also affects the functioning of organizations as it may reduce worker productivity and team performance (Aguilar-Gomez *et al*., 2022), cause poor leadership behaviors (Khan *et al*., 2024), hurt organizational innovation (Wang *et al*., 2021), and result in productivity loss for manufacturing firms (Fu *et al*., 2021). To our knowledge, no prior research has examined the effects of air pollution on the functioning specifically of nonprofit organizations. Yet there is good reason to believe that such impacts exist. In the rest of this section, we make a first attempt to understand the relationship between air quality and nonprofit capacity by examining the effects of air pollution on donations and volunteering in nonprofit organizations.

2.2 Theory and hypothesis development

2.2.1 Air pollution and donations. The existing literature on the antecedents and drivers of charitable giving has focused mostly on micro- (e.g. the characteristics of individual donors) or meso-level (e.g. donors' social networks) factors (Bekkers and Wiepking, 2011; Sargeant and Woodliffe, 2007), with very limited attention to macro-level factors (e.g. community characteristics or ecological and climatic conditions; for a notable exception, see

Prentice, 2015). One stream of research related to macro-level antecedents and drivers of charitable giving focuses on people's prosocial behavior in the wake of disasters, and the findings generally show an increase in charitable donations in response to natural disasters such as earthquakes, tsunamis, and hurricanes, as well as man-made disasters such as the September 11, 2001 terrorist attacks (Brown and Minty, 2008; Douty, 1972; Schwirplies, 2023; Steinberg and Rooney, 2005). People also tend to respond differently to natural disasters than to those caused by human actions. For example, an experimental study found that participants donated more money to victims of famine when the cause was natural rather than human-caused (Zagefka *et al.*, 2011).

Disasters or crises aside, other environmental factors such as weather and seasons are also found to play a role in affecting charitable behavior (see Mainardes *et al.*, 2017). For example, Bekkers and Wiepking's (2011) literature review on the drivers of charitable giving suggests that people are less likely to donate to charities when weather conditions create physical discomfort. In a set of experiments involving charitable donation scenarios, Rai *et al.* (2017) find cold (vs. warm) temperature cues lead to greater intentions to donate to charities because cold temperature cues trigger people's need for social connection, which in turn increases their willingness to engage in prosocial behavior such as monetary donations and volunteer work. In a recent study of the effects of the outbreak of COVID-19 on spontaneous charitable donations in Sweden, Erlandsson *et al.* (2022) find that donations were unaffected by the pandemic outbreak but fluctuated substantially from season to season: less donations in January–February and during the summer months, and more donations in April–May and during the last months of the year.

Empirical evidence specifically focused on the impacts of hazardous air quality on charitable giving, however, is limited. To address this gap, we build on the economics and sociology literature to identify two mechanisms through which air pollution potentially decreases charitable giving. The first mechanism is related to household income. The conventional wisdom projects a positive relationship between household income and charitable giving, with higher-income households giving more to charity (Clotfelter, 1985; Steinberg, 1990). Several studies have revealed that higher levels of air pollution lead to increases in hospital admissions (Mann *et al.*, 2002) and direct health care costs (Alexeeff *et al.*, 2022). Such deterioration of personal health and increase in health care costs effectively reduce the amount of disposable household income, which in turn results in lower levels of private donations to local nonprofits.

The second mechanism is related to social capital (Adler and Kwon, 2002; Putnam, 2000), or the social resources embedded in networks of civic engagement that are vital to the health of the nonprofit sector (Saxton and Benson, 2005). Social capital is considered a key prerequisite for sustainable development (Pawlewicz and Cieślak, 2024) along with other social, organizational, and community outcomes (Putnam, 2000; Ressler *et al.*, 2021), including charitable giving (Brooks, 2005; Wang and Graddy, 2008) and volunteering (Brown and Ferris, 2007; Wakefield *et al.*, 2001). Air pollution however, fuels risk-averse behaviors, discouraging outdoor activities and fostering isolation (Bresnahan *et al.*, 1997), thereby weakening the social bonds and interactions essential to building social capital (Zeng *et al.*, 2022) while also potentially "crowding out" prosocial and pro-environmental behaviors (Ming *et al.*, 2022). Along this line, some recent work has suggested that poor air quality has the potential to disrupt the bonds nonprofit organizations have with their donors. Notably, Saxton *et al.* (2024) find that county-level charitable giving as a percentage of adjusted gross income is lower in counties with worse air quality. They posit that the negative relation is a result of weaker civic engagement and a reduction in social capital in areas with worse air quality. Their county-level study helps inform what we might find at the *organization-level*. Namely, that nonprofit organizations in areas with worse air quality can expect lower levels of monetary donations [1].

Both mechanisms predict a negative and linear relationship between air pollution and monetary donations, and yet the elasticity of human behavior in response to air pollution might not necessarily be constant across the air pollution spectrum. In particular, an individual is unlikely to act on air pollution unless they are aware of its severity; when air quality gradually worsens but has not yet reached the level of hazardous air pollution, it might not trigger a human response due to the lack of public awareness: As Evans and Jacobs (1981) noted, public awareness of air pollution depends heavily on direct perceptual experience more so than on mass media coverage. This is consistent with the notion of the *availability heuristic* (Tversky and Kahneman, 1973), which suggests that individuals are more likely to respond to events that are vivid, extreme, and easily recalled. Hazardous air days – though rare – are more likely to generate public warnings, media attention, and heightened psychological salience, while more moderate pollution levels may be perceived as background conditions and thus fail to prompt behavioral change. The consideration of the above two mechanisms and the cognitive framing leads to our first hypothesis:

H1. Donations to nonprofit organizations will be negatively related to hazardous air pollution.

2.2.2 Air pollution and volunteering. Turning to volunteering, at first glance, it seems reasonable to predict that volunteering with nonprofit organizations will also be negatively related to air quality. The volunteering literature indicates that people's health status influences their volunteer activity, with poor health reducing one's ability to donate time (Caputo, 1997) and the amount of time one donates (Gallagher, 1994; Wilson and Musick, 1997). Since air pollution harms people's physical and mental health, this likely reduces both the capability and time available for volunteering service.

Yet the decision to give time and/or money is complex and driven by a variety of factors. Importantly, the relationship may be complementary or substitutive. Prior literature establishes that, under normal circumstances, individuals with prosocial orientations tend to engage in both charitable giving and volunteering activities, suggesting a complementary relationship between the two (Brown and Lankford, 1992; Freeman, 1997). However, specific to our setting, poor air quality has been shown to reduce trust in local public institutions (Yao *et al.*, 2022), which may lead to lower levels of monetary and time contributions (Brown and Ferris, 2007).

While charitable giving and volunteering activities can be complementary, there are times they act as substitutes. For example, Feldman (2010) demonstrates that monetary donations and volunteer time vary by the tax-price of donations and essentially act as substitutes. Jones' (2006) empirical study provides compelling evidence for this in showing that "giving and volunteering represent distinct means of engagement" (p. 249) that, in the United States at least, are increasingly acting as substitutes. Consistent with the behavioral framing in the previous section (Tversky and Kahneman, 1973), this substitution effect appears to become more pronounced under extraordinary circumstances such as natural disasters or when donors face severe financial constraints. For instance, Guo and Peck (2009) show that individuals receiving public assistance increase their volunteer time while giving less financially. Similarly, Voorintholt (2023) finds that, under budget constraints, donating and volunteering function as substitutes. In the context of natural disasters, Kawawaki (2023) finds that, in the aftermath of the 2011 Great East Japan Earthquake, volunteering decreased with distance from the disaster area, likely due to the elevated opportunity cost, while monetary donations increased.

In line with this evidence, in the context of poor air quality, the substitution of time for money may become even more pronounced – particularly when pollution levels reach a threshold that makes the environmental threat vivid and salient. While overall social capital may be diminished in such environments, individuals may still choose to engage with specific nonprofit organizations that align closely with their values or concerns. Brown *et al.* (2019) find that individuals derive greater utility from gifts of time than from gifts of financial resources. In addition, in areas with poor air quality where trust in institutions is lower (Yao *et al.*, 2022), individuals may prefer to volunteer rather than donate financially, consistent with research showing a preference for time-based contributions (Costello and Malkoc, 2022). As such, areas with poor air quality may see an increase in volunteerism from concerned citizens seeking to contribute in more personally meaningful or value-aligned ways, even as monetary donations decline. However, this increased volunteering may not manifest across the nonprofit industry. For example, individuals might seek volunteering opportunities at organizations that provide psychological relief or community connection during environmental stress. For instance, arts organizations and mutual benefit associations may see increased volunteering, as they offer indoor activities and opportunities for social connection that provide relief from environmental stressors. Other nonprofit types such as educational organizations might not experience the same level of increase in volunteering. Still, while the specific destinations of volunteering may vary and be difficult to predict *a priori*, we believe the aggregate effect is likely to be an overall rise in volunteerism. This leads to our second hypothesis:

H2. Volunteering to nonprofit organizations will be positively related to hazardous air pollution.

3. Data and method

3.1 Sample selection

Table 1 summarizes our sample selection, which starts with all 501(c)(3) nonprofit IRS 990 e-filings available as of February 2024, totaling 2,314,512 observations. The sample is then refined by excluding duplicate organization/year filings, filings from 2009 and 2023 (excluded due to lack of air quality data), filings in US territories, filings without county codes, filings in counties without air quality data, and filings with missing or invalid data. Our sample is further reduced by lagging control variables, which necessitates excluding observations from the first year of the dataset and those with missing lagged data. Our final sample comprises 1,633,529 filings by 248,749 unique nonprofit organizations.

Table 2 provides descriptive data on our sample observations by tax year (Panel A) and industry (Panel B). As shown in Panel A, given the increasing prevalence of electronic filing of the Form 990 over time, the percentage of observations increases steadily each year. Panel B, in turn, categorizes the observations by industry, using the 10 major NTEE (National Taxonomy of Exempt Entities) categories. The largest category is Human Services (HU), comprising 35.55% of the total observations with 580,725 filings. This is followed by Education (ED) with 257,826 filings, making up 15.78% of the total, and Health (HE) with 242,390 filings, accounting for 14.84% of the sample. At the other end of the spectrum, the smallest categories are International (IN) and Mutual Benefit (MU), with 37,283 and 4,461 filings, respectively, representing 2.28 and 0.27% of the total observations.

Table 1. Sample selection

Criteria	N
All 501(c)(3) nonprofit IRS 990 e-filings (2009–2023)	2,314,512
Less duplicate organization/year filings	(2,110)
Less 2009; 2023 filings (no county AQI data)	(28,186)
Less nonprofits in US Virgin Islands, Puerto Rico, Guam, Northern Mariana Islands, American Samoa, Federated States of Micronesia, and Palau	(3,057)
Less missing county FIPS code	(3,299)
Less filings in counties without AQI data	(370,609)
Less filings with missing/invalid data, lagged variables	(273,730)
Total observations (990 filings)	1,633,529*

Note(s): *248,749 unique 501(c)(3) organizations

Source(s): Authors' own creation

Table 2. Observations by filing year and industry

Panel A. Number of observations by tax year

Year	N	%
2010	19,076	1.17
2011	70,819	4.34
2012	92,253	5.65
2013	105,351	6.45
2014	117,854	7.21
2015	130,618	8.00
2016	139,509	8.54
2017	147,033	9.00
2018	154,038	9.43
2019	162,169	9.93
2020	173,324	10.61
2021	188,593	11.55
2022	132,892	8.14
Total	1,633,529	*100%*

Panel B. Number of observations by industry (10 Major NTEE Categories)

NTEE Category	N	%
AR: arts, culture, humanities	152,397	9.33
ED: education	257,826	15.78
EN: environment	72,514	4.44
HE: health	242,390	14.84
HU: human services	580,725	35.55
IN: international	37,283	2.28
MU: mutual benefit	4,461	0.27
PU: public/societal benefit	193,387	11.84
RE: religion	87,874	5.38
UN: other/unknown	4,672	0.29
Total	1,633,529	*100%*

Source(s): Authors' own creation

3.2 Model

To test our hypotheses, we specify two panel regression models where donations received by and volunteers to nonprofit organizations, respectively, are functions of severe air pollution, a range of control variables, and industry, state, and year fixed effects (FE), as follows:

$$DONATIONS_{i,t} = \beta_0 - \beta_1 HAZARDOUS\,DAYS_{i,t} + \sum_{k=1}^{K} \beta_k CONTROLS_{i,t-1} + FE + \epsilon \quad (1)$$

$$VOLUNTEERS_{i,t} = \beta_0 + \beta_1 HAZARDOUS\,DAYS_{i,t} + \sum_{k=1}^{K} \beta_k CONTROLS_{i,t-1} + FE + \epsilon \quad (2)$$

3.3 Dependent variables: donations and volunteers

Our first dependent variable, *Donations*, is measured as the log of direct donations derived from IRS Form 990 data. Specifically, in line with previous literature (e.g. Harris *et al.*, 2023), direct donations are measured as total contributions less government grants and federated campaigns. We then scale the variable by 1,000,000s and apply a log transformation. Our second dependent variable, *Volunteers*, is measured as the log of the number of volunteers who work with the organization.

3.4 Independent variable: air quality

We gather county-level air quality data from the EPA (US Environmental Protection Agency, 2024) and matched nonprofit organizations to county-level air quality data based on the county of their location as indicated in the Form 990 data. The air quality data is available annually from 2010 to 2022 for slightly over 1,000 counties per year. Air quality index (AQI) values of 0–50 are considered "good," 51–100 "moderate," 101–15- "unhealthy for sensitive groups," 151–200 "unhealthy," 201–300 "very unhealthy," and 301 and higher "hazardous" (US Environmental Protection Agency, 2023). Because we are interested in the presence of severely poor air quality, our key independent variable, *Hazardous Days*, measures the number of days in the year having an AQI value 301 or higher. In employing the highest threshold of air quality, we follow research focusing on extreme events, which, while rare, can have an outsize impact on behavior and social phenomena [2]. 14,702 of our observations include at least one hazardous air day. Furthermore, approximately 1.5% of county-years and almost 8% of US counties experience hazardous air days in our sample.

3.5 Control variables

Using IRS Form 990 data, we control for the measures typically included in the nonprofit accounting literature for examining the determinants of donations (e.g. Calabrese and Grizzle, 2012; Harris *et al*., 2023; Jacobs and Marudas, 2009; Kaden *et al*., 2022; Quosigk and Forgione, 2018): *Fundraising Expenses*, calculated as the log of fundraising expenses; *Age*, representing the log of the number of years since the organization's IRS ruling; *Program Expense Ratio*, defined as program service expenses divided by total expenses; *Size*, logged total assets; *Government Grants*, logged amount of government grants received; *Program Service Revenue*, logged revenues from program services; *Governance*, measured as an index of seven governance items following Boland *et al*. (2020) and *Employees*, measured as the log of number of employees.

To help control for county-level factors, we also incorporate two county-level controls. First, to control for rural-urban differences that might be associated with either air pollution or our outcomes, we code *Rural* as a binary variable using the USDA's rural-urban continuum (US Department of Agriculture, 2023). Specifically, those counties with codes 8 or 9 – which reflect counties that are "completely rural or less than 2,500 urban population, adjacent to a metro area" and "completely rural or less than 2,500 urban population, not adjacent to a metro area," respectively – are assigned values of 1, otherwise 0. Second, to help control for socio-economic factors that might be related to air pollution, donating, and volunteering, we measure the *Poverty Rate* as the percentage of families in the county with income below the federal poverty rate (US Census Bureau, 2022). Definitions for all variables are found in the appendix.

4. Results

4.1 Descriptive statistics

Table 3 presents our sample summary statistics (Panel A) and a correlation matrix (Panel B). As shown in Panel A, the scaled (in $1,000,000s) dependent variable, *Donations*, has a mean of 1.624, a standard deviation of 25.320, and ranges from 0 to 9265.12 [3]. The dependent variable *Volunteers* has a mean of 125.568 and ranges from 0 to 3,061. The independent variable, *Hazardous Days*, has a mean of 0.037 and a range from 0 to 26. For the control variables, the means for *Fundraising Expenses*, *Age*, *Program Expense Ratio*, *Size*, *Government Grants*, *Program Service Revenue*, *Governance*, and *Employees* are 0.128, 25.289, 0.812, 24.721, 1.083, 9.464, 4.371, and 70.8, respectively. The mean values on our two county-level controls, *Rural* and *Poverty Rate*, are, respectively, 0.002 and 10.108.

4.2 Hypothesis tests

Table 4 presents the main hypothesis test results examining the empirical relationship between *Hazardous Days* and, respectively, *Donations* and *Volunteers*. We find *Hazardous Days* is significantly, negatively associated with *Donations* in column (1) and significantly, positively

Table 3. Summary statistics and correlations

Panel A: Summary statistics

	N	Mean	SD	Min	P25	Median	P75	Max
Dependent Variable								
Donations	1,633,529	1.624	25.320	0	0.008	0.124	0.495	9265.12
Volunteers	1,633,529	125.568	411.524	0	0	9	58	3061
Independent Variable								
Hazardous Days	1,633,529	0.037	0.461	0	0	0	0	26
Control Variables								
Fundraising Expenses	1,633,529	0.128	1.538	0	0	0	0.028	289.183
Age	1,633,529	25.289	18.703	0	11	21	36	122
Program Expense Ratio	1,633,529	0.812	0.195	0	0.756	0.857	0.941	1
Size	1,633,529	24.721	395.480	0	0.24	0.919	3.993	75287.516
Government Grants	1,633,529	1.083	23.054	0	0	0	0.072	13197.193
Program Service Revenue	1,633,529	9.464	191.975	0	0	0.063	0.565	68337.727
Governance Index	1,633,529	4.371	1.432	0	3	5	5	7
Employees	1,633,529	70.8	240.466	0	0	4	28	1,831
Rural	1,633,529	0.002	0.050	0	0	0	0	1
Poverty Rate	1,633,529	10.108	4.162	0	6.86	9.89	12.81	35.87
Service-Oriented	1,633,529	0.516	0.500	0	0	1	1	1
Sophisticated Donors	1,633,529	0.249	0.432	0	0	0	0	1

Panel B: Pairwise correlations

Variables	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)	(9)	(10)	(11)	(12)	(13)
(1) Donations	1												
(2) Volunteers	0.345*	1											
(3) Hazardous Days	−0.006*	0.000	1										
(4) Fundraising Expenses	0.644*	0.284*	−0.008*	1									
(5) Age	0.145*	0.196*	−0.003*	0.178*	1								

(*continued*)

Table 3. Continued

Panel B: Pairwise correlations

Variables	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)	(9)	(10)	(11)	(12)	(13)
(6) Program Expense Ratio	0.003*	0.002*	0.001	−0.051*	0.021*	1							
(7) Size	0.526*	0.245*	−0.013*	0.488*	0.305*	0.017*	1						
(8) Government Grants	0.237*	0.142*	0.001	0.263*	0.139*	0.075*	0.347*	1					
(9) Program Service Revenue	0.240*	0.170*	−0.010*	0.298*	0.220*	0.081*	0.685*	0.245*	1				
(10) Governance Index	0.370*	0.356*	−0.016*	0.291*	0.264*	0.001	0.453*	0.285*	0.312*	1			
(11) Employees	0.376*	0.328*	−0.002*	0.361*	0.303*	0.042*	0.541*	0.439*	0.653*	0.488*	1		
(12) Rural	−0.014*	−0.011*	0.003*	−0.011*	0.003*	0.002*	−0.013*	−0.004*	−0.009*	−0.017*	0.002*	1	
(13) Poverty Rate	0.039*	−0.041*	0.000	0.026*	−0.013*	−0.009*	0.037*	0.056*	0.020*	0.038*	−0.001	0.040*	1

Note(s): All continuous variables (*Donations, Volunteers, Fundraising Expenses, Age, Size, Government Grants, Program Service Revenue*, and *Employees*) are logged and winsorized in our multivariate tests, but we present unlogged versions above for ease of interpretation. Continuous variables are winsorized at the 1st and 99th percentiles. Financial variables (*Donations, Fundraising Expenses, Size, Government Grants, Program Service Revenue*) are scaled by $1,000,000s
*p < 0.05

Source(s): Authors' own creation

Table 4. Air quality, donations, and volunteers: Main hypothesis tests

	DV =			
	Donations (1)		Volunteers (2)	
Hazardous $Days_t$	−0.001**	(−3.146)	0.008*	(2.111)
Fundraising $Expenses_{t-1}$	1.831**	(2148.866)	1.931**	(215.830)
Age_t	−0.021**	(−105.328)	0.166**	(81.195)
Program Expense $Ratio_{t-1}$	0.060**	(72.916)	0.073**	(8.551)
$Size_{t-1}$	0.088**	(449.594)	0.031**	(15.086)
Government $Grants_{t-1}$	−0.060**	(−184.488)	−0.185**	(−54.152)
Program Service $Revenue_{t-1}$	−0.129**	(−501.924)	−0.220**	(−81.886)
Governance $Index_{t-1}$	0.023**	(169.947)	0.371**	(261.704)
$Employees_{t-1}$	0.038**	(316.842)	0.255**	(201.718)
$Rural_{t-1}$	−0.032**	(−10.117)	−0.448**	(−13.483)
Poverty $Rate_{t-1}$	−0.0001	(−0.692)	−0.039**	(−84.688)
Constant	−0.089**	(−28.517)	−0.318**	(−9.662)
Industry, State, and Year Fixed Effects	YES		YES	
Observations	1,633,529		1,633,529	
Adjusted R^2	0.838		0.222	
F	99,738.743**		5,495.588**	

Note(s): Table shows coefficients from robust regressions, with *t*-stats in parentheses; $+ p < 0.10$, $*p < 0.05$, $**p < 0.01$ (two-tailed). Robust regressions eliminate gross outliers (i.e. where Cook's distance >1), and automatically down-weights outliers and influential observations in the estimation process, providing more reliable coefficient estimates than OLS when data contain extreme values or influential cases. See Appendix for variable definitions

Source(s): Authors' own creation

associated with *Volunteers* in column (2). In suggesting that severe air pollution adversely affects charitable contributions but positively affects volunteering, these findings support both Hypothesis 1 and Hypothesis 2. While the main coefficients may seem small, it is important to keep in mind that the donations dependent variable is in logged millions of dollars. As such, a one-day increase in the number of hazardous days is associated with a 0.1% decrease in donations, a 10-day increase in hazardous days is associated with a 1% drop in donations, and a 26-day increase a 2.6% drop in donations. While these numbers may seem small, for an organization at the mean level of donations (approximately $1.624 million), moving from no to 10 hazardous days is associated with an approximately $16,000 drop in donations. While that may not seem like a large amount, the year-over-year impact of a drop in donations for six consecutive years of hazardous air would be close to $100,000. Such a decrease could have real programmatic impacts for many of the average nonprofits in our study.

The results in Table 4 similarly provide empirical support for our second hypothesis. The increase in volunteers, however, is heartening and suggests that, as noted by prior research (Feldman, 2010; Guo and Peck, 2009; Jones, 2006), there may be a substitution effect with monetary donations. An increase in hazardous levels of air pollution per year is associated with an approximately 0.8% increase in volunteering. For nonprofits with, for example, 100 volunteers, we would expect a *ceteris paribus* increase in approximately 8 volunteers in moving from no hazardous days to 10 hazardous days and an increase of nearly 24 volunteers by moving from zero to 26 hazardous days. We should also stress that, compared to the larger substantive effects seen in our instrumental variables and entropy-balanced robustness tests in the two following sub-sections, Table 4 should be taken to present conservative estimates of the impact of our independent variable on donations and volunteering.

4.3 Instrumental variables analysis

As with any OLS regression, there is the possibility that the above results could be spurious due to endogeneity. To address possible endogeneity concerns, we implement two core strategies.

First, we employ instrumental variables (IV) analysis on our primary independent variable, *Hazardous Days*, to address potential endogeneity issues arising from omitted variable bias. Leveraging prior work on instrumental variables for air pollution (Godzinski and Suarez Castillo, 2021; Saxton *et al.*, 2024; Wu and Pu, 2020), we chose as our instrument a county-level measure of Gini inequality. This instrument meets the relevance and exclusion criteria for valid instruments by being empirically related to *Hazardous Days* but not directly affecting the level of charitable donations nor volunteering. The *Gini Inequality Index*, taken from the American Community Survey (US Census Bureau, 2022), captures income inequality, which can be correlated with industrial activities and environmental degradation without directly influencing charitable giving. This instrument passes the standard diagnostic tests for instrumental variables, confirming its validity and relevance in this context. The IV models allow us to reject the null hypothesis of the under identification test, with highly significant Chi-squared values. Our tests also meet the criteria for a non-weak instrument: the *Gini Inequality Index* model has a significant Cragg-Donald Wald F statistic of 1,574.784 that exceeds the Stock-Yogo (2005) critical value of 16.38 for 10% maximal IV size.

Table 5 shows the results of the IV analyses. The results in column (1) of Table 5 show a significant negative relationship between *Hazardous Days* and *Donations*, reinforcing H1. Similarly, the results in column (2), as in Table 4, reinforce H2 in showing a significant positive relationship with *Volunteers*. Once again, these results highlight the complex dynamics between air quality and charitable behavior, providing further evidence for a substitution effect between monetary donations and volunteering.

4.4 Entropy-balanced sample analyses

While the IV tests help address endogeneity concerns flowing from omitted variable bias and reverse causality, there is also the potential for endogeneity due to systematic differences between organizations in high and low air pollution areas. To address this concern, we employ entropy balancing to reweight the data and ensure that observable covariates are balanced across groups. In effect, entropy balancing is used to help control for pre-existing observable characteristics that could be influencing the relationship between air quality and donations. We

Table 5. Air quality, donations, and volunteers: instrumental variables tests

	DV =			
	Donations (1)		Volunteers (2)	
Hazardous Days$_t$	−2.067**	(−36.173)	0.652**	(5.418)
Fundraising Expenses$_{t-1}$	1.227**	(289.548)	1.694**	(189.949)
Age$_t$	−0.035**	(−35.002)	0.163**	(78.381)
Program Expense Ratio$_{t-1}$	0.140**	(33.650)	0.102**	(11.581)
Size$_{t-1}$	0.169**	(172.468)	0.031**	(15.078)
Government Grants$_{t-1}$	−0.053**	(−33.070)	−0.175**	(−51.451)
Program Service Revenue$_{t-1}$	−0.161**	(−124.785)	−0.203**	(−74.898)
Governance Index$_{t-1}$	0.038**	(55.873)	0.356**	(247.417)
Employees$_{t-1}$	0.056**	(92.150)	0.241**	(189.918)
Rural$_{t-1}$	−0.037*	(−2.312)	−0.487**	(−14.420)
Poverty Rate$_{t-1}$	0.003**	(14.511)	−0.038**	(−78.215)
Constant	−0.126**	(−8.735)	−0.380**	(−12.531)
Industry, State, and Year Fixed Effects	YES		YES	
Observations	1,500,617		1,500,617	
F	3,542.310**		4,855.683**	

Note(s): Table shows coefficients from 2SLS instrumental variables regressions, with *t*-stats in parentheses; + $p < 0.10$, *$p < 0.05$, **$p < 0.01$ (two-tailed). The instrument for *Hazardous Days* is the *Gini Inequality Index*. See Appendix for variable definitions

Source(s): Authors' own creation

first classify observations into two groups based on air pollution exposure: those located in counties with zero *Hazardous Days*, which comprise the "control" group, and those in counties with one or more *Hazardous Days*, which comprise the "treatment" group. We then estimate entropy balance weights on the mean, variance, and skewness (Hainmueller, 2012) for all covariates that allow us to run weighted regressions where the treatment and control groups are balanced on all control variables.

Table 6 shows two panels related to the entropy balancing tests. As reflected in the mean values across groups, Panel A shows the covariate balance between organizations in the *No Hazardous Days* and *Any Hazardous Days* groups before and after weighting. We also show the standardized differences in means pre- and post-weighting. In line with Hainmuller (2012),

Table 6. Air quality, donations, and volunteers: entropy-balanced tests

Panel A. Covariate balance pre- and post-entropy balancing

	Mean – Pre-entropy balancing			Mean – Post-entropy balancing		
	No Hazardous Days	Any Hazardous Days	Stdzed diff. in means	No Hazardous Days	Any Hazardous Days	Stdzed diff. in means
Fundraising Expenses	0.064	0.042	−0.100	0.040	0.042	0.000
Age	2.963	2.919	−0.050	2.918	2.919	0.000
Program Expense Ratio	0.812	0.815	0.010	0.816	0.815	0.000
Size	1.139	0.953	−0.140	0.953	0.953	0.000
Government Grants	0.201	0.224	0.040	0.224	0.224	0.000
Program Service Revenue	0.500	0.377	−0.120	0.376	0.377	0.000
Employees	1.975	1.881	−0.050	1.882	1.881	0.000
Governance Index	4.375	4.043	−0.230	4.042	4.043	0.000
Rural	0.002	0.003	0.010	0.003	0.003	0.000
Poverty Rate	10.096	10.960	0.210	10.960	10.960	0.000

Panel B. Entropy-balanced sample regressions

	DV =			
	Donations (1)		Volunteers (2)	
Any Hazardous Days	−0.014**	(−19.514)	0.069**	(17.995)
Fundraising Expenses$_{t-1}$	1.636**	(696.277)	2.584**	(207.790)
Age$_t$	−0.035**	(−96.933)	0.184**	(95.601)
Program Expense Ratio$_{t-1}$	0.147**	(98.051)	0.102**	(12.785)
Size$_{t-1}$	0.183**	(453.191)	0.003	(1.468)
Government Grants$_{t-1}$	−0.076**	(−128.822)	−0.179**	(−57.235)
Program Service Revenue$_{t-1}$	−0.162**	(−302.789)	−0.256**	(−90.306)
Governance Index$_{t-1}$	0.029**	(121.913)	0.351**	(282.566)
Employees$_{t-1}$	0.043**	(188.731)	0.191**	(157.679)
Rural$_{t-1}$	−0.030**	(−5.717)	−0.545**	(−19.625)
Poverty Rate$_{t-1}$	−0.002**	(−22.590)	−0.036**	(−77.956)
Industry, State, and Year Fixed Effects	YES		YES	
Observations	1,633,609		1,633,609	
F	18,070**		4,971**	
Adj. R^2	0.485		0.205	

Note(s): In line with Hainmuller (2012), Panel A shows mean values and standardized difference in means for the control variables in the low and high air pollution groups before and after entropy balancing. Panel B shows coefficients from weighted regression (using weights derived from entropy balancing), with t-stats in parentheses; *p < 0.05, **p < 0.01 (two-tailed). Any Hazardous Days is a binary variable indicating organizations in a county with one or more Hazardous Days. See Appendix for variable definitions.

Source(s): Authors' own creation

covariates with a standardized difference above 0.1 can be considered “imbalanced.” In Panel A we see that five of our controls – *Fundraising Expenses, Size, Program Service Revenue, Governance Index,* and *Poverty Rate* – exceed the threshold. This means our model is a good candidate for entropy balancing. After generating and applying the entropy balancing weights, the standardized difference in means for all control variables is, as expected, 0.

Panel B shows the results from the two weighted regressions where the independent variable is the binary measure *Any Hazardous Days*. The results are consistent with Tables 4 and 5, indicating that high air pollution has a significant negative relationship with donations and a significant positive relationship with volunteering, with the relationships remaining robust even after balancing the sample to control for potential confounding factors.

4.5 Robustness tests

We ran a number of untabulated sensitivity analyses to assess the robustness of our findings to alternative specifications. First, we ran calendar-year regressions, where we limited observations to those that have a January to December fiscal year. We also ran the regressions using lagged *Hazardous Days*. In both tests the coefficient on *Hazardous* Days was significantly negatively related to *Donations* and significantly positively related to *Volunteers.* We also ran separate analyses restricting our sample to exclude environmental nonprofits; the results show no change in either the sign or statistical significance of our *Hazardous Days* variable, suggesting that our main findings are not driven by environmental organizations’ potentially unique relationship with air quality issues.

In some cases, the county of the organization’s address in Form 990 data may not be the same area as the geographic location served by the organization. Given that the air quality data is matched with the location as given in the 990 data, there is a potential for geographic mismatches between the nonprofit’s headquarters and the areas served. However, the great majority of nonprofits have a single location, and the local chapters of large national organizations are generally treated as separate entities in the 990 data. That said, we acknowledge that prior research suggests that the headquarters-satellite issue might be more significant for larger public charities, which are more likely to have multiple locations (see Peck, 2008), or for mutual benefit public charities, which distribute funds to operating public charities and might lead to double counting (Joassart-Marcelli and Wolch, 2003). To further validate our findings, we therefore conducted two additional tests: (1) following Peck (2008), we performed a robustness check using only smaller organizations (below the 75th percentile in asset size); and (2) following Joassart-Marcelli and Wolch (2003), we excluded mutual benefit public charities from our analysis. These additional tests yielded results consistent with our main findings, reinforcing the validity of our approach and ensuring that the observed relationships are not driven by potential mismatches between the geographic scope of nonprofit activities and the air quality data.

Our final robustness check is regarding the instrumental variables analysis. While our *Gini Inequality Index* instrument passes all diagnostics and plausibly meets the relevance and exclusion criteria, there is a possibility that its exclusion restriction, while plausible, may be challenging to verify definitively given its potential relationship with charitable giving. To check whether our IV results are robust to an alternative instrument, we also run the IV analysis using *Emergency Room Visits for Asthma Cases*, which measures county-level annual emergency room visit rates for asthma (US Centers for Disease Control and Prevention, 2024), as our instrument. *Emergency Room Visits for Asthma Cases* provides a health-based proxy for pollution exposure that is highly responsive to acute spikes in air pollution (Peden, 2002) but unlikely to influence charitable giving directly, especially at the county level, where such medical events typically go unnoticed by the broader population (Pate and Zahran, 2024). Reassuringly, the results are even stronger with this alternative instrument.

4.6 Conditioning effect of industry sub-sector (NTEE code)

Environmental conditions, particularly hazardous air quality, do not affect all nonprofit organizations equally. Differences in mission, service delivery models, and resource dependencies across nonprofit sub-sectors may influence their resilience to environmental challenges. To deepen our understanding of these dynamics, we conduct four sets of additional analyses. To start, we analyze whether the relationship between air pollution and nonprofit outcomes varies across 10 industry sub-sectors as classified by the National Taxonomy of Exempt Entities (NTEE). This analysis helps uncover how nonprofit organizations in specific sectors respond to and are affected by air pollution, providing valuable insights for developing tailored strategies to enhance organizational resilience.

Table 7 explores the interactions between *Hazardous Days* and the 10 NTEE codes; the omitted, or baseline, category is educational organizations (ED). The results in Table 7 indicate that the impact of poor air quality on donations varies significantly across different nonprofit subsectors. Notably, the interaction terms for environmental organizations (EN), health organizations (HE), human service organizations (HU), and religious organizations (RE) in the *Donations* regression are significantly positive, suggesting that those organizations related to the potential causes and impacts of air pollution receive more donations as air pollution increases. These organizations likely show increased donation needs during periods of poor air quality, as they must expand their programmatic efforts to address the environmental

Table 7. Air quality, donations, and volunteers: Interactions with industry sub-sector (NTEE codes)

	DV =			
	Donations (1)		Volunteers (2)	
Hazardous Days$_t$	−0.004**	(−3.988)	0.002	(0.336)
AR (Arts)	0.019**	(28.705)	0.456**	(66.000)
EN (Environment)	0.070**	(82.072)	0.742**	(82.947)
HE (Health)	0.022**	(37.858)	−0.012**	(−1.985)
HU (Human Services)	−0.011**	(−22.128)	0.167**	(33.056)
IN (International)	0.165**	(146.330)	0.058**	(4.933)
MU (Mutual Benefit)	−0.026**	(−8.517)	−0.299**	(−9.353)
PU (Public/Societal Benefit)	0.037**	(61.065)	0.101**	(15.692)
RE (Religious)	0.091**	(114.176)	−0.047**	(−5.659)
UN (Unknown)	0.025**	(8.489)	0.157**	(5.028)
Hazardous Days × AR	−0.0002	(−0.155)	0.060**	(3.972)
Hazardous Days × EN	0.004**	(2.816)	0.006	(0.421)
Hazardous Days × HE	0.003*	(2.063)	−0.010	(−0.749)
Hazardous Days × HU	0.004**	(3.907)	−0.008	(−0.705)
Hazardous Days × IN	0.001	(0.276)	−0.045	(−1.506)
Hazardous Days × MU	0.0001	(0.016)	0.129$^+$	(1.781)
Hazardous Days × PU	−0.001	(0.724)	0.016	(1.058)
Hazardous Days × RE	0.004*	(1.999)	0.021	(1.072)
Hazardous Days × UN	0.004	(0.743)	0.037	(0.721)
Control Variables	YES		YES	
State and Year Fixed Effects	YES		YES	
Observations	1,633,529		1,633,529	
Adjusted R^2	0.838		0.222	
F	90182.653**		4969.970**	

Note(s): Table shows coefficients from robust regressions, with *t*-stats in parentheses; + $p < 0.10$, *$p < 0.05$, **$p < 0.01$ (two-tailed). Robust regressions eliminate gross outliers (i.e. where Cook's distance >1), and automatically down-weights outliers and influential observations in the estimation process, providing more reliable coefficient estimates than OLS when data contain extreme values or influential cases. The omitted (baseline) category is Education organizations (NTEE category *ED*). See Appendix for variable definitions

Source(s): Authors' own creation

challenges [4]. We suggest this offers additional empirical support for linking nonprofit outcomes and air pollution in future large-N research.

For the *Volunteers* regressions, in turn, only two interactions are significant: both arts organizations (AR) and mutual benefit organizations (MU) are significantly positive, suggesting increased levels of volunteering in response to severe air pollution. These findings run counter to what might be initially expected: health and environmental organizations do not receive greater increases in volunteering. Instead, the most pronounced effects occur in sectors less directly tied to air quality. This pattern suggests that during periods of environmental stress, individuals may be drawn to volunteering opportunities that offer emotional relief or social connection rather than direct engagement with the causes of the crisis. Arts organizations typically offer indoor, low-risk engagement, while mutual benefit associations foster social ties and community solidarity – both of which may be especially appealing during periods of environmental stress. These findings underscore the complex relationship between environmental stressors and civic engagement and highlight the importance of accounting for psychological and social motivations – not just issue alignment – when predicting volunteering behavior. Overall, the relationship between air pollution and philanthropic behavior is not uniform, reinforcing the importance of sub-sector-specific strategies to mitigate air pollution's effects on giving and volunteering.

These sub-sector effects underscore that mission alignment and donor salience likely shape the philanthropic response to air pollution. To further probe this point, we conducted an additional test focusing exclusively on the subset of nonprofit organizations classified as environmental (EN). While the interaction term for environmental organizations in Table 7 was significantly positive – indicating that environmental nonprofits receive more donations relative to the baseline (education nonprofits) – the environmental-only subsample tells a more nuanced story. When we restrict the sample to just environmental organizations and re-estimate the models for donations and volunteering, the coefficient on *Hazardous Days* is no longer statistically significant. Yet this result does not necessarily contradict the Table 7 findings; rather, it reflects the shift from a relative comparison (environmental versus other types) to an absolute one (environmental only), and highlights the methodological and interpretive challenges of working with a small, homogeneous subsample that comprises just 4.4% of the full dataset. The lack of statistical significance may stem from limited variation in air pollution exposure or from reduced statistical power. Taken together, our results suggest that while environmental nonprofits do respond differently to air pollution events in a relative sense, the signal may be harder to detect in isolation. While we chose not to tabulate these environmental-only results due to the limited sample size, lack of a natural comparison group, and reduced interpretive power, we summarize them here given their conceptual relevance. Future research could build on this by using more granular, event-level, or regional data to better isolate how environmental nonprofits – or other types of organizations – uniquely mobilize resources in response to severe pollution events.

4.7 Conditioning effect of service-oriented organizations

Beyond industry-specific factors, the financial and operational structures of nonprofits may condition their vulnerability to environmental challenges. Service-oriented organizations, which rely heavily on fees-for-services rather than donations, may exhibit distinct responses to air pollution compared to donor-oriented organizations. To explore this dynamic, we examine whether the relationship between hazardous air quality and nonprofit outcomes differs for service-oriented organizations. Although our main analyses include industry dummy variables to indirectly account for these differences in donor reliance and solicitation practices, we also performed additional analyses to explicitly capture these variations. To examine the differential impact of air pollution on donations and volunteering in organizations that operate more service-oriented businesses, we interacted *Hazardous Days* with an indicator variable for service-oriented enterprises. Following Balsam and Harris (2014), we classify

Service-Oriented organizations as equal to one for organizations with a ratio of program service revenues to total revenues exceeding the sample median (13%). These service-oriented organizations are less dependent on donations to fund their programs and may, therefore, be impacted differently by air pollution.

Table 8 presents the analyses looking at the interaction between *Hazardous Days* and *Service-Oriented*. As expected, service-oriented organizations are associated with significantly lower donations, as indicated by the significant negative coefficient on *Service-Oriented*. However, the significant positive coefficient on our main coefficient of interest, *Hazardous Days* × *Service-Oriented*, suggests that donations to service-oriented organizations increase in response to severe air pollution more so than for donor-oriented organizations. In the volunteering regression, in contrast, the significantly negative coefficient on *Hazardous Days* × *Service-Oriented* suggests that severe air pollution reduces volunteering for service-oriented organizations more than for donor-oriented organizations. Collectively, these two regressions suggest that while service-oriented nonprofits in areas with severe air pollution obtain more donations than other nonprofits, they also appear to experience a greater decline in volunteer engagement. This finding underscores the dual nature of service-oriented organizations' financial resilience and highlights the importance of diversifying engagement strategies to navigate environmental challenges effectively.

4.8 Conditioning effect of sophisticated donors

The characteristics of an organization's donor base play a pivotal role in shaping its response to external shocks, including environmental crises. Organizations with sophisticated donors, defined as those with restrictions on net assets, may experience different dynamics in

Table 8. Air quality, donations, and volunteers: conditioning effect of service-oriented

	DV =			
	Donations (1)		Volunteers (2)	
Hazardous Days_t	−0.002**	(−4.334)	0.014*	(2.836)
Service-Oriented_t	−0.108**	(−294.508)	−0.383**	(−98.488)
Hazardous Days × Service-Oriented_t	0.002**	(2.296)	−0.015*	(−2.095)
Fundraising Expenses_{t-1}	1.806**	(2148.698)	1.863**	(208.576)
Age_t	−0.017**	(−89.129)	0.177**	(86.636)
Program Expense Ratio_{t-1}	0.080**	(99.856)	0.125**	(14.537)
Size_{t-1}	0.078**	(400.768)	−0.0001	(−0.002)
Government Grants_{t-1}	−0.078**	(−240.601)	−0.230**	(−66.953)
Program Service Revenue_{t-1}	−0.095**	(−346.395)	−0.109**	(−37.575)
Governance Index_{t-1}	0.024**	(179.108)	0.373**	(264.034)
Employees_{t-1}	0.040**	(338.578)	0.261**	(206.539)
Rural_{t-1}	−0.032**	(−10.176)	−0.441**	(−13.331)
Poverty Rate_{t-1}	−0.0002**	(−4.270)	−0.039**	(−85.999)
Constant	−0.060**	(−19.276)	−0.192**	(−5.835)
Industry, State, and Year Fixed Effects	YES		YES	
Observations	1,633,529		1,633,529	
Adjusted R^2	0.843		0.227	
F	100775.746**		5530.351**	

Note(s): Table shows coefficients from robust regressions, with *t*-stats in parentheses; + $p < 0.10$, *$p < 0.05$, **$p < 0.01$ (two-tailed). Robust regressions eliminate gross outliers (i.e. where Cook's distance >1), and automatically down-weights outliers and influential observations in the estimation process, providing more reliable coefficient estimates than OLS when data contain extreme values or influential cases. *Service-Oriented* organizations are those with a ratio of program service revenues to total revenues exceeding the sample mean. See Appendix for variable definitions

Source(s): Authors' own creation

donations and volunteering during periods of hazardous air quality. Sophisticated donors are often more attuned to cues about organizational performance (Yetman and Yetman, 2013) and environmental conditions, which may amplify their responsiveness to changes in air quality. Accordingly, as a further extension of our main analyses, we divided our results based on the sophistication of the organizations' donor base. In line with Yetman and Yetman (2013), we identify organizations with temporary or permanent restrictions on their net assets as having more sophisticated donors. We show regressions with our binary measure of *Sophisticated Donors* interacted with *Hazardous Days* in Table 9. The significant negative coefficient on *Hazardous Days* × *Sophisticated Donors* in the donations model suggests that organizations with sophisticated donors experience reduced donations in the context of severe air pollution compared to organizations without sophisticated donors, consistent with sophisticated donors being relatively more responsive to negative cues. In the volunteering model, in turn, we do not find a significant coefficient on *Hazardous Days* × *Sophisticated Donors*, suggesting that volunteering in organizations is coming from a committed stakeholder base that may be in part distinct from the sophisticated donor's base.

4.9 Tests of the "crowding out" argument

In our previous analyses, we consistently demonstrated a negative relationship between air pollution and donations. While donations are the primary revenue source for many nonprofits, government funding also plays a crucial role, particularly subsequent to climate change-related disasters when government support often increases (Simo and Bies, 2007). However, the interaction between these two funding sources raises an important question: does government funding "crowd out" private donations? This question is especially relevant in the

Table 9. Air quality, donations, and volunteers: Conditioning effect of sophisticated donors

	DV =			
	Donations (1)		Volunteers (2)	
Hazardous $Days_t$	−0.001*	(−2.019)	0.011*	(2.641)
Sophisticated $Donors_t$	0.085**	(189.016)	0.809**	(172.040)
Hazardous Days × Sophisticated $Donors_t$	−0.002**	(−1.974)	−0.015	(−1.642)
Fundraising $Expenses_{t-1}$	1.808**	(2130.271)	1.803**	(203.178)
Age_t	−0.023**	(−117.976)	0.140**	(68.722)
Program Expense $Ratio_{t-1}$	0.063**	(77.224)	0.104**	(12.248)
$Size_{t-1}$	0.081**	(414.576)	−0.008**	(−4.011)
Government $Grants_{t-1}$	−0.056**	(−172.519)	−0.154**	(−45.643)
Program Service $Revenue_{t-1}$	−0.120**	(−467.139)	−0.168**	(−62.730)
Governance $Index_{t-1}$	0.019**	(137.316)	0.328**	(229.830)
$Employees_{t-1}$	0.035**	(294.191)	0.233**	(185.030)
$Rural_{t-1}$	−0.030**	(−9.689)	−0.434**	(−13.197)
Poverty $Rate_{t-1}$	0.0001	(1.521)	−0.038**	(−83.760)
Constant	−0.095**	(−30.472)	−0.416**	(−12.754)
Industry, State, and Year Fixed Effects	YES		YES	
Observations	1,633,529		1,633,529	
Adjusted R^2	0.839		0.237	
F	97708.621**		5835.815**	

Note(s): Table shows coefficients from robust regressions, with *t*-stats in parentheses; + $p < 0.10$, *$p < 0.05$, **$p < 0.01$ (two-tailed). Robust regressions eliminate gross outliers (i.e. where Cook's distance >1), and automatically down-weights outliers and influential observations in the estimation process, providing more reliable coefficient estimates than OLS when data contain extreme values or influential cases. Organizations with *Sophisticated Donors* are those reporting temporary or permanent restrictions on their net assets. See Appendix for variable definitions

Source(s): Authors' own creation

context of climate change-related disasters, where the allocation of public funds might alter donor behavior.

To address this question, we extend our analysis to explore the potential crowding-out effect. Crowding out occurs when government funding displaces contributions from private donors, a phenomenon debated extensively in the nonprofit finance literature (Andreoni and Payne, 2003; Grasse *et al*., 2022; Kim and Mason, 2020; Tinkelman and Neely, 2018). While prior research offers mixed evidence (Grasse *et al*., 2022), Tinkelman and Neely (2018) conclude from a review of 54 studies that crowding out, when observed, tends to be modest. By examining this dynamic in the context of hazardous air quality, we aim to provide new insights into how nonprofits can strategically balance their revenue sources in response to environmental challenges.

Table 10 presents the results of regression analyses aimed at examining the potential crowding out effect of government grants on charitable donations and volunteering in the context of heightened air pollution. We therefore interact *Government Grants* with *Hazardous Days* in regressions of *Donations* and *Volunteers*. The significant negative coefficient on *Hazardous Days* × *Government Grants* in both regressions is consistent with a crowding out effect.

4.10 Heterogeneous effects by county context: urbanization and poverty

While our main regression models include county-level controls for rural–urban status and poverty rate, these variables may also function as proxies for long-term exposure to poor air quality. Chronic pollution – such as that stemming from industrial emissions or persistent vehicle traffic – tends to be more prevalent in urban areas and lower-income communities, where environmental regulation and infrastructure investment may be weaker. In contrast, acute air pollution events, such as wildfires, are more transient and less likely to systematically

Table 10. Air quality, donations, and volunteers: Crowd-out test

	DV =			
	Donations (1)		Volunteers (2)	
Hazardous Days$_t$	−0.0005	(−1.234)	0.013*	(3.305)
Government Grants$_{t-1}$	−0.060**	(−183.441)	−0.184**	(−53.706)
Hazardous Days × Government Grants$_{t-1}$	−0.005**	(−6.581)	−0.027**	(−3.804)
Fundraising Expenses$_{t-1}$	1.831**	(2148.607)	1.930**	(215.757)
Age$_t$	−0.021**	(−105.333)	0.166**	(81.188)
Program Expense Ratio$_{t-1}$	0.060**	(72.910)	0.073**	(8.544)
Size$_{t-1}$	0.088**	(449.618)	0.031**	(15.102)
Program Service Revenue$_{t-1}$	−0.129**	(−501.943)	−0.220**	(−81.911)
Governance Index$_{t-1}$	0.023**	(169.965)	0.371**	(261.724)
Employees$_{t-1}$	0.038**	(316.852)	0.255**	(201.732)
Rural$_{t-1}$	−0.032**	(−10.110)	−0.447**	(−13.476)
Poverty Rate$_{t-1}$	−0.00003	(−0.709)	−0.039**	(−84.699)
Constant	−0.090**	(−28.534)	−0.319**	(−9.675)
Industry, State, and Year Fixed Effects	YES		YES	
Observations	1,633,529		1,633,550	
Adjusted R^2	0.838		0.222	
F	98581.098**		5431.921**	

Note(s): Table shows coefficients from robust regressions, with *t*-stats in parentheses; + $p < 0.10$, *$p < 0.05$, **$p < 0.01$ (two-tailed). Robust regressions eliminate gross outliers (i.e. where Cook's distance >1), and automatically down-weights outliers and influential observations in the estimation process, providing more reliable coefficient estimates than OLS when data contain extreme values or influential cases. See Appendix for variable definitions

Source(s): Authors' own creation

erode trust or alter giving behavior. To investigate whether air pollution has differential effects across these community contexts, we conduct two sets of subsample analyses by estimating our main models separately for organizations in rural (*Rural* = 1) versus non-rural (*Rural* = 0) counties, and for those in counties with *Poverty Rate* values below and above the sample median.

The untabulated results reveal meaningful heterogeneity. The negative relationship between *Hazardous Days* and donations is concentrated in urban (non-rural) counties, consistent with the idea that chronic pollution erodes trust in institutions and suppresses financial giving. Conversely, the positive relationship between air pollution and volunteering is most pronounced in high-poverty areas, suggesting a substitution effect whereby financially-constrained individuals may respond to environmental stress by donating time rather than money. While these subsample analyses offer only an indirect test of the chronic-versus-acute pollution distinction, they provide promising preliminary evidence of contextual heterogeneity. The observed heterogeneity underscores the need for future research to disentangle the effects of chronic versus acute air pollution, as each may activate different mechanisms – such as institutional distrust or short-term mobilization – that shape charitable behavior in distinct ways. These findings support our broader theoretical framing and highlight how the effects of environmental stressors on nonprofit engagement are conditioned by structural and socioeconomic context. We return to this point in the following section.

5. Discussion and conclusions

In this study, we provide some of the first empirical evidence supporting a relationship between air pollution and engagement with nonprofit organizations. A series of multivariate analyses point to a robust relationship between the presence of a high number of "hazardous" air quality days (AQI above 301) and charitable activity. Consistent with our first hypothesis, we find significantly lower donation levels in areas with poor air quality. We suggest that it is also important to note that the potential year-over-year decrease in donations related to hazardous air conditions might be substantial for some nonprofits. Our second hypothesis was also supported in that we found a consistent and positive relationship between poor air quality and the extent of volunteering.

Our additional analyses highlight the importance of considering how organizational characteristics – such as sub-sector, service orientation, donor sophistication, and reliance on government funding – moderate the relationship between air pollution and civic engagement. For example, our sub-sector analyses suggest that organizations connected to the causes and impacts of air pollution (environmental, health, human service, and religious organizations) receive more donations as pollution levels increase. This indicates that donor elasticity likely varies depending on both the organization's purpose and the nature of the environmental challenge. These findings suggest an important boundary condition for our first hypothesis, highlighting how organizational mission can shape the relationship between environmental stressors and charitable behavior.

From a practical perspective, our findings suggest that nonprofit organizations should develop differentiated strategies based on the nature of the air quality challenges they face. For organizations in areas with chronic air pollution from persistent industrial emissions, our results imply that building long-term donor relationships rather than crisis-oriented fundraising would be more effective, as donors in these areas may become less responsive to air quality fluctuations over time. Building these long-term relationships is particularly important if the nonprofit organization is perceived to be adequately funded through other funding sources such as government grants. Indeed, our main hypothesis tests suggest that the average nonprofits in the most polluted areas might expect to receive more volunteers (as much as a 23% increase). Given the potential higher baseline of volunteer interest in high-pollution areas, these organizations should also develop year-round volunteer engagement programs that can effectively channel this potential resource. Nonprofits may also benefit from staggered engagement strategies that reflect the differing temporal dynamics of giving and volunteering that are implicit in our findings. Namely, our findings are consistent with prior research suggesting that monetary donations often occur as immediate responses to a crisis, while volunteering tends to emerge more gradually (Kawawaki, 2023). If that is the case, then structuring outreach accordingly may help organizations maximize both forms of engagement over time.

Our additional analyses suggest the need for other sector-specific strategies in response to environmental crises – especially for nonprofits operating in high-risk environments. Arts and mutual benefit organizations, which see increased volunteering during periods of poor air quality, should develop specific volunteer opportunities that can be activated during crisis periods. Given our finding that donations tend to increase for organizations connected to the causes and impacts of air pollution, environmental, health, and human service organizations in particular should consider message framing that connects donations to systemic solutions for ongoing air quality issues. Building relationships with sophisticated donors prior to crises also seems to be important, since these donors appear to be more responsive to environmental cues and reduce giving during periods of poor air quality. All organizations should consider the potential crowding-out effect we identified between government grants and private donations during air quality crises. Strategic partnerships should be pursued to help sustain funding continuity and reduce reliance on any single revenue source, and nonprofits should clearly communicate the need for private support above and beyond public funding sources.

While this study provides valuable insights into the relationship between air quality and charitable donations and volunteering, several limitations should be noted that suggest areas for future research. First, the analysis relies on data from IRS Form 990 filings and the EPA, which may have inherent biases or limitations in coverage and accuracy. Specifically, the Form 990 data, while generally a reliable data source, is known to have some errors including omission of data and transposition mistakes (Feng *et al*., 2014). However, to the extent that there is measurement error in our data we expect a bias against finding statistically significant results. The reliance on observational data also means that causality cannot be definitively established, despite the use of robust statistical methods such as entropy balancing and instrumental variables analysis.

A second set of limitations relates to the nature of the environmental data. First, the use of annual data limits our ability to observe short-term responses to pollution events. Future work leveraging high-frequency or event-level data could help uncover more precise temporal dynamics in giving and volunteering. Second, while our subsample analyses based on urbanization and poverty provide a preliminary, indirect test of the distinction between acute ("shock") and chronic air pollution, we are unable to directly test this distinction with the current data. Finally, while our framework acknowledges the distinction between natural and human-caused pollution sources – which prior work suggests may provoke different charitable responses (Zagefka *et al*., 2011) – our data do not permit empirical comparison along this dimension. Future research could address these limitations by using more granular environmental and behavioral data to explore how the timing, duration, and perceived cause of pollution events shape patterns of civic engagement. Limitations notwithstanding, the consistent statistically significant relationships between hazardous air pollution and nonprofit engagement suggest this is a promising area for further study.

Future research could address current limitations by incorporating more granular and diverse data sources, by exploring the impact of other environmental factors, and by employing experimental or longitudinal designs to better establish causal relationships. Moreover, investigating the role of digital and social media engagement in shaping donor responses to air pollution could provide deeper insights into effective fundraising strategies in an increasingly digital world. Finally, our study has not considered the effects of air pollution on nonprofit program delivery and resource allocation. Since no prior research has explored this topic, it is a particularly promising direction for future research that would go a long way toward enhancing our understanding of how environmental conditions such as air pollution could impact the capacity and sustainability of nonprofits. Future research could also explore the mechanisms underlying sophisticated donors' reduced giving during periods of environmental stress, including whether this behavior reflects greater risk sensitivity, strategic selectivity, skepticism about nonprofit effectiveness, or heightened responsiveness to environmental cues.

Notwithstanding these limitations, this study contributes to the literature by empirically linking environmental factors to charitable behavior, demonstrating the significant influence of climate-related events on donor and volunteer engagement. Our findings build on the established "economic model of giving" (Weisbrod and Dominguez, 1986) in the economics and accounting literature (e.g. Calabrese and Grizzle, 2012; Harris *et al*., 2015; Jacobs and Marudas, 2009; Kaden *et al*., 2022; Quosigk and Forgione, 2018; Saxton *et al*., 2014) by introducing air pollution as an important but previously unexplored factor at the organizational level. From a practical perspective, these insights suggest that nonprofits in polluted areas should strengthen their communication and engagement strategies to mitigate reduced donations, while policymakers and grantmakers should consider incorporating environmental risks into nonprofit financial management practices. As climate-related events become more frequent and severe, understanding the impact of air pollution on donation and volunteering patterns is critical for ensuring the financial and civic health of the nonprofit sector. Nonprofits should engage the local community and build up levels of trust that may have declined over time due to poor air quality. Taken together, our results underline the importance of considering environmental factors when studying economic and social behaviors.

Appendix

Table A1. Variable definitions

Variable	Definition and source
Dependent Variables	
Donations	Log of direct donations, where direct donations is total contributions [Form 990 Part VIII, line 1 h] – contributions from federated campaigns [Form 990 Part VIII, line 1a] – government grants [Form 990 Part VIII, line 1e], all scaled by $1,000,000
Volunteers	Log of number of volunteers [Form 990 Part I, line 6]
Independent Variable	
Hazardous Days	Number of days in the year having an AQI (air quality index) value 301 or higher. [US EPA]
Control Variables	
Fundraising Expenses	Log of fundraising expenses [Form 990 Part IX line 25 column D]
Age	Log of number of years since IRS ruling [IRS Business Master File]
Program Expense Ratio	Program service expenses/Total expenses [Form 990 Part IX line 25 column B]/[Form 990 Part IX line 25 column A]
Size	Log of total assets [Form 990 Part X line 16]
Government Grants	Log of government grants received [Form 990 Part VIII, line 1e]
Program Service Revenue	Log of program service revenue [Form 990 Part VIII, line 2 g, column A]
Governance Index	Following Boland *et al*. (2020), measured as the summation of seven items from the Form 990: 1) personnel disclose conflicts of interest; 2) other key personnel's compensation is approved; 3) financial statements reviewed or audited by independent accountants; 4) documentation of the governing body meeting minutes; 5) disclosure of applicable forms on website; 6) key personnel reachable at organization's address; and 7) organization has at least five voting board members with the majority classified as independent
Employees	Log of number of employees [Form 990 Part I, line 5]
Rural	Binary variable where counties with USDA rural-urban continuum codes 8 and 9 (indicating rural areas) are assigned values of 1, otherwise 0. Source: USDA (2023)
Poverty Rate	Percent of families in county with income below the poverty rate (US Census Bureau, 2022)
Service-Oriented	Binary variable where values equal 1 for organizations with a ratio of program service revenues to total revenues [Form 990 Part VIII, line 12, column A] exceeding the sample median; 0 otherwise
Sophisticated Donors	Binary variable where values equal 1 for organizations reporting temporary or permanent restrictions on their net assets, otherwise 0 [Form 990 Part X lines 28–29]
State	State in which organization is located [Form 990 header]
Industry	10-category industry (NTEE) code [IRS Business Master File]
Year	Tax year of filing [Form 990 header]

Source(s): Authors' own creation

Notes

1. Note that Hypothesis 1 assumes donors reside in the same county as the nonprofit they support. Prior research consistently demonstrates a strong donor preference for giving to local organizations (see Breeze, 2013; Chapman *et al*., 2022; Grimson *et al*., 2020), a tendency labeled by some as "local altruism" (Giudici *et al*., 2018). Giving locally reduces information asymmetry, strengthens donors' connections to causes impacting their immediate community, and increases their confidence in achieving direct impact through their donations.

2. For example, other high-threshold events such as extreme weather, extreme environmental events, and extreme political events (e.g. extraordinary rain, 100-year blizzards, hurricanes, extreme heat, droughts, war, civil war, coups, etc.) are often employed as predictors of phenomena such as poverty,

development, maternal health, mental health, investment, immigration, etc. For example, interstate wars, which occur in less than 0.0002 of dyadic interactions (Palmer *et al.*, 2021), are regularly recognized to have an outsized impact on behavior. Hazardous air days do not occur in every US county, but it does occur in an important proportion of counties (8%), and it is important relative to some environmental variables (e.g. blizzards and hurricanes) in that it is not limited to specific regions of the US.

3. All continuous variables are logged and winsorized at the 1st and 99th percentiles in our multivariate analyses. However, unlogged values are presented here for ease of interpretation. Continuous financial variables (*Donations, Fundraising Expenses, Size, Government Grants,* and *Program Service Revenue*) are scaled in millions of dollars.

4. For example, environmental organizations, whose missions directly address air quality issues, appear to see increased donations during periods of severe air pollution, as these events increase the salience and perceived importance of their work. This would be consistent with research showing that issue salience drives charitable giving to relevant causes (Brown and Minty, 2008). The increased visibility of environmental problems during air pollution events may motivate donors to support organizations working on solutions, creating an exception to the overall negative relationship we expected.

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