Maastricht University

UNU MERIT

Working Paper Series

#2026-004

Airless democracy: Air pollution and voter turnout

Giulia Rossello, Maria Antonietta Reatini, Gabriele Pinto, and Giorgio Cattani

Published 23 February 2026

DOI: https://www.doi.org/10.53330/SJEH1088

Maastricht Economic and social Research institute on Innovation and Technology (UNU-MERIT)
email: **info@merit.unu.edu** | website: **http://www.merit.unu.edu**

Boschstraat 24, 6211 AX Maastricht, The Netherlands
Tel: (31) (43) 388 44 00

UNU-MERIT Working Papers
ISSN 1871-9872

Maastricht Economic and social Research Institute on Innovation and Technology UNU-MERIT

UNU-MERIT Working Papers intend to disseminate preliminary results of research carried out at UNU-MERIT to stimulate discussion on the issues raised.

Airless Democracy: Air Pollution and Voter Turnout

Giulia Rossello[a], Maria Antonietta Reatini[b], Gabriele Pinto[c], and Giorgio Cattani[b]

[a] Department of Management and Economics, University of Pisa, Italy

[b] Italian Institute for Environmental Protection and Research, ISPRA, Italy

[c] Department of Social and Economic Sciences, La Sapienza, Italy

Abstract

Air pollution is a major externality whose consequences extend beyond health and productivity. This paper shows that short-run pollution shocks also reduce democratic participation. We combine official, municipality-level election results from 32 national, European, regional, and municipal elections in Italy (2013-2022) with newly assembled daily measures of $PM_{2.5}$, PM_{10}, and NO_2 for all Italian municipalities. Our identification strategy exploits quasi-random election-day deviations in local pollution relative to recent conditions, and we corroborate the results using wind speed as an instrument for particulate matter. Higher pollution on election day substantially depresses turnout: a 10 $\mu g/m^3$ increase in $PM_{2.5}$ (roughly doubling typical exposure) lowers participation by 2-3 percentage points, corresponding to about one million fewer votes. The estimates are similar for PM_{10} and NO_2, and when pollution exceeds WHO guideline thresholds. Using post-election survey data from the 2013, 2018, and 2022 national elections coupled with survey-date exposure, we find consistent individual-level declines in reported voting intentions, with larger effects among citizens who report higher political interest. These findings identify the political-economy cost of air pollution, which not only reduces turnout but distorts the democratic representation by altering who turns out, not just how many. Our results suggest that environmental regulation can strengthen the democratic process by improving political participation and representation, in addition to its health and welfare benefits.

Keywords: Air Pollution; Environmental Effects; Political Participation; Turnout.

Jel codes: Q51, Q53, D72, D91

1. Introduction

Air pollution is the number one threat to human life; according to the World Health Organization (WHO), it contributes to 9% of global deaths each year (Pryor et al., 2022). Common air pollutants, especially fine particulate matter (PM), such as $PM_{2.5}$, penetrate the lungs and enter the bloodstream, triggering systemic inflammation, oxidative stress, long-term damage to vital organs, and adverse psychological reactions such as stress, anxiety, and depression (Yu et al., 2025; Braithwaite et al., 2019). Indeed, the literature on the adverse effects of air pollution has documented that the short-run effects of exposure to air pollution extend beyond physical health and shape how people think and act (Bellani et al., 2024; Hunnicutt and Henderson, 2023; Herrnstadt et al., 2021).

High levels of air pollution reduce attention and impair memory (Lavy et al. 2014), lower labor productivity (Zivin and Neidell, 2012), increase violent crimes (Herrnstadt et al., 2021), and reduce job seekers' search effort and reservation wage (Bogaard et al., 2024).

Following the idea that short-run exposure to air pollution impacts the cognitive process affecting decision-making, researchers have recently asked whether effects extend to voting behavior (Bellani et al., 2024; Hunnicutt and Henderson, 2023). Prior work on air pollution and voting behavior is still limited and delivers mixed results. Bellani et al. (2024) studied 60 German National and Federal elections (2000–2018), using election-day PM_{10} as within-county variation across election dates. They find a small positive effect of PM_{10} on turnout that becomes statistically insignificant once time-varying controls are added, while reporting a negative effect on the incumbent vote share. In contrast to us, they only consider election day levels of PM_{10} without identifying an exogenous variation in exposure to air pollution or employing an instrumental variable. Hunnicutt and Henderson (2023) provide a more convincing identification strategy; however, their data are limited to the Western U.S. and span only two years. In particular, they focus on political participation outside elections, using wind speed as an instrument for $PM_{2.5}$, and examining 414 Western U.S. counties (2019-2021). They find that higher air pollution reduces participation in political organization meetings.

Overall, the reason behind this lack of consistency in empirical results likely reflects differences across studies in methodology, how pollution and participation are measured, the time horizon considered, and the samples analyzed. This heterogeneity underscores the need for more systematic evidence, covering multiple election types, geographic units, and time periods, to assess whether and when air pollution exposure translates into changes in political behavior.

Indeed, this line of research faces two key challenges: (1) the technical difficulty in creating a large-scale sample of daily measures of air pollutants at the required geographic granularity; and (2) developing a credible identification strategy that addresses major threats to causal inference, especially omitted-variable bias and reverse causality.

Our paper contributes to this literature by addressing both challenges and delivering large-scale causal estimates of the effect of air pollution on electoral turnout, with a focus on short-run fluctuations in exposure to air pollutants on election day. First, we overcome the measurement constraints on the geographical granularity by leveraging the latest advances in environmental science developed by the Italian Institute for Environmental Protection and Research (ISPRA). Specifically, we assemble municipality-level daily concentrations of $PM_{2.5}$, PM_{10}, and NO_2 for the period 2013-2022. This dataset allows us to document the causal relationship across time and space, covering all election types and all municipalities in Italy over a decade (2013-2022). Second, to identify the causal effect of air pollution on electoral turnout, we exploit the random variation in exposure to $PM_{2.5}$ on election day relative to preceding days. We further test the robustness of the relation, including fluctuations in exposure relative to alternative time windows, considering other measures or pollutants (PM_{10} and NO_2) and WHO air-quality threshold levels, and implementing an instrumental variable approach that exploits wind speed. In addition, we examine individual-level effects and investigate potential mechanisms using the available survey data, exploiting day-to-day variation in $PM_{2.5}$ exposure in respondents' municipality of residence on the interview date.

Our results find a consistent negative relationship between exposure to air pollutants on election day and voter turnout. The effect is consistent across models and pollutant measures. In our most conservative and preferred estimations, a spike in election-day $PM_{2.5}$ corresponding to a 10 microgram per cubic meter ($\mu g/m^3$) increase, roughly doubling typical exposure, lowers turnout by 2-3 percentage points, implying roughly 1 million fewer votes, comparable to the entire population of a large Italian city such as Bergamo or Turin.

Lastly, individual-level survey data confirms the aggregate estimates after controlling for individual characteristics and political views. In terms of mechanisms, the individual-level analysis suggests that the level of interest in politics can moderate the relationship between turnout and air pollution. In particular, individuals with a higher interest in politics are more discouraged by an increase in the concentration of air pollution. Suggesting that air pollution depresses, in particular, the participation of politically "conscious" individuals. This mechanism requires further scrutiny and additional survey data, but if confirmed has severe implications in democratic participation with potentially far-reaching consequences for both policy and society. If short-run pollution spikes disproportionately discourage politically engaged citizens, then poor air quality can do more than harm health; it can subtly distort democratic representation by changing who shows up at the polls, not just how many.

Overall, our results raise an environmental-justice concern as well. Because pollution exposure is unevenly distributed across places and social groups, air quality may translate into unequal political voice. From a policy perspective, our findings imply that air-quality regulation can yield democratic as well as public-health benefits, and that election management should treat extreme pollution episodes as a barrier to participation.

2. Political Behavior and Air Pollution

The effect of air pollution on political behavior is complex and ambivalent. The ambivalence mirrors a broader strand of the economics literature on political discontent, which shows that locally concentrated adverse shocks, reflecting policy failures, can reshape political behavior through competing mechanisms. In this literature, negative shocks such as globalization (Autor et al.,2020; Barone and Kreuter, 2021; Caselli, Fracasso and Traverso, 2020), automation (Frey et al., 2018; Anelli, Colantone, and Stanig, 2019), and economic crises (Algan et al., 2017; Guiso et al., 2019, 2024) generate geographic-based grievances that fuel ideological realignment, increasing protest or populist votes. But empirical results are ambiguous on its effect on participation, with adverse shocks either increasing (Autor et al., 2020; Caselli, Fracasso and Traverso, 2020) or decreasing (Barone and Kreuter, 2021; Guiso et al., 2019; Algan et al., 2017) turnout. This suggests that shocks can either mobilize individuals or demobilize and depress electoral participation when disillusionment and rising participation costs dominate (Barone and Kreuter, 2021; Guiso et al., 2019; Algan et al., 2017).

Air pollution can be understood in the same framework: a shock that is spatially uneven, experienced in daily life, and potentially attributable to a policy failure.

From the theoretical standpoint, we can distinguish direct and indirect pathways through which air pollution shapes political behavior. Direct pathways operate when pollution becomes politically salient, either because it is visible, publicly discussed, or highlighted by alerts and media coverage. In this case, pollution functions as an explicit and deliberate cue (Bellani et al., 2024) and a policy failure creating political grievance (Hunnicutt and Henderson, 2023). Individuals may attribute responsibility to incumbents or institutions, update their evaluations of government performance, and respond intentionally by changing vote choice, participating in protests, or otherwise engaging to demand policy action.

From this perspective, the direct pathway implies a positive relation between air pollution and political participation. Air pollution is a policy failure that mobilizes individuals (Hunnicutt and Henderson, 2023). This direct channel is closely aligned with the political-discontent literature, where adverse shocks become politically meaningful when they are interpretable as policy failures and can be blamed on incumbents or institutions, triggering protest and populist vote (Autor et al., 2020; Barone and Kreuter, 2021; Caselli, Fracasso and Traverso, 2020; Frey et al., 2018; Anelli, Colantone, and Stanig, 2019; Algan et al., 2017; Guiso et al., 2019, 2024). In these settings, grievance can mobilize electoral participation as individuals respond intentionally to perceived losses or neglect (Autor et al., 2020; Caselli, Fracasso and Traverso, 2020).

In contrast, indirect pathways operate even when pollution is not consciously recognized as a political issue. Here, pollution works as a subtle and subconscious influence (Bellani et al., 2024) and as part of the lived experience of daily life (Hunnicutt and Henderson, 2023). By affecting physical well-being (Deryugina et al., 2019; Anderson, 2020), mood (Yu et al., 2025), depression, anxiety (Braithwaite et al., 2019), and cognitive functioning (Lavy et al. 2014), air pollution can raise the costs of participation, reduce motivation or capacity to engage, and reshape judgment and preferences, without requiring explicit blame or grievance formation.

Thus, the indirect pathways of the subconscious daily-life experience of air pollution point to a negative relationship with political participation. The physical and psychological effects of air pollution reduce political engagement similarly to other health and time constraints that increase the costs of collective action (Hunnicutt and Henderson, 2023). Exposure worsens respiratory conditions and other health outcomes (Deryugina et al., 2019). These health shocks can translate into lower productivity and labor supply (He, Liu, and Salvo, 2019; Hoffmann and Rud 2024; Borgschulte, Molitor and Zou 2024), increase negative emotions (Braithwaite et al., 2019), and therefore depress civic engagement (Verba, Schlozman, and Brady, 1995).

At the same time, economic research on political discontent emphasizes that shocks can also reduce political participation: insecurity and declining trust can depress turnout (Algan et al., 2017; Guiso et al., 2019; Barone and Kreuter, 2021). Pollution's indirect health, emotional, and cognitive impacts map naturally onto this logic because they increase the costs of engagement and reduce the resources, like time, energy, and attention, needed for participation.

Air pollution can influence political behavior either way. Which effect dominates depends on the context, including how observable pollution is, how strongly it is politicized, and how participation costs vary across individuals and settings. In line with this perspective, air pollution can simultaneously raise the barriers to collective action (through health, time, and psychological burdens) and strengthen grievances that motivate engagement. As suggested in Hunnicutt and Henderson (2023), the aggregate effect observed in data therefore reflects the relative strength of direct and indirect pathways in a given setting. A negative relationship, for example, would be consistent with a scenario in which the number of individuals demobilized because pollution increases the costs of participation exceeds the number of those mobilized by political grievances. Ex ante, air pollution may be more likely to reduce political participation. Indeed, while all individuals experience the physical effects of air pollution, not everyone who experiences them becomes politically aggrieved (Hunnicutt and Henderson, 2023), implying that the demobilizing channel may operate more broadly and more frequently.

The empirical research that examines the relationship between air pollution and political behavior is still limited and provides mixed results. Bellani et al. (2024) examine the effect of PM_{10} on the share of votes for incumbent parties and on voter turnout, focusing on 60 National and Federal German elections from 2000 to 2018. To estimate the causal effect of air pollution, they used the level of PM_{10} on election day, claiming that the level of observed PM_{10} on election day is an idiosyncratic variation in air pollution within the same county across election dates, representing a deviation from the level of pollution on a "typical election day" in a given county. They find a slightly positive effect of PM_{10} on turnout, but the effect becomes non-statistically significant when time-varying controls are included. Examining the type of votes, they find a negative effect on the share of votes for incumbent parties, suggesting no effect on political participation but a potential shift in political support. In contrast, Hunnicutt and Henderson (2023) focused on political participation rather than electoral turnout, examining the effect of $PM_{2.5}$ on the number of commitments for participating in meetings of a political organization in 414 counties in the Western United States between 2019 and 2021. To identify the causal impact on political participation, they used wind speed as an instrument for $PM_{2.5}$ concentrations, finding a negative relationship between air pollution and political participation.

The limited and contrasting results suggest that important gaps remain. While the health impacts of air pollution are extensively documented and widely accepted, the evidence on non-health effects, particularly those operating through decision-making, is comparatively fragmented. These outcomes are harder to observe directly, more sensitive to context, and often entangled with confounding factors such as socio-economic conditions. As a result, isolating causal pathways and quantifying the magnitude of these behavioral impacts remains challenging despite the expanding literature. This paper fills this gap by providing large-scale causal evidence on the effect of short-run air pollution shocks on electoral participation, combining municipality-level election returns for all Italian municipalities (2013-2022) with newly assembled daily measures of $PM_{2.5}$, PM_{10}, and NO_2 and leveraging quasi-random election-day variation in exposure, complemented by a wind-speed as instrument, and individual-level survey evidence.

3. Data

In this section, we describe our data and variable construction. Our data collection is twofold. First, we collected municipality-level data to run a panel analysis representing municipalities for each election 2013-2022, including electoral data, socio-economic, weather, and air pollution data. Second, we collect a repeated cross-section of individual survey data to perform the individual-level analysis by linking air pollution on a certain day to the interview date and the place of residence of the respondent.

3.1 Electoral Data

For the analysis at the municipality level, we collected municipality-level electoral data, including all types of elections held between 2013 and 2022 from Eligendo, the open data repository of the Italian

Ministry of the Interior.[1] The data includes electoral results of 7210 Italian municipalities: (1) three national camera elections held in 2013, 2018, and 2022; (2) two European elections held in 2014 and 2019, (3) Regional elections where several regions were called to elect their representatives in 2013, 2014, 2015, 2018, 2019, 2020, and 2021, and (4) all municipality elections 2013-2022. Table A1 in the Appendix shows the number of municipalities voting in each election, we can observe that in almost every year, we have a set of municipalities voting (this is due to the staggered timing of municipal and regional election in Italy that for historical reason do not occur on the same year for all municipalities).

From these electoral data, we construct for each municipality, date, type of election, and voter turnout. Voter turnout is computed as the ratio between the number of people who vote in the election and registered voters multiplied by 100.

3.2 Socio-Economic

To account for the socio-economic characteristics of Italian municipalities, we rely on the ISTAT municipality census data 2013-2022. The data collected includes the number of the resident population, the percentage of individuals with a university degree, and the employment rate.

3.3 Weather Data

For this research, meteorological variables including temperature, precipitation, pressure, and wind are obtained from two data sources: the Air Operational System modeling suite (kAIROS) for the period 2020-2022 and the Copernicus European Regional ReAnalysis (CERRA) containing sub daily regional reanalysis datasets on single levels for the period 2013-2019. The kAIROS Air Operational System is an advanced air quality modelling suite developed to provide operational atmospheric composition forecasts over Italy. It couples the latest versions of the multi-scale chemistry-transport model CHIMERE with the Consortium for Small-scale Modeling (COSMO) meteorological model (Stortini et al, 2020). CERRA provides a high-resolution reconstruction of past atmospheric conditions over Europe. Reanalysis products offer physically consistent atmospheric fields by optimally combining numerical model simulations with a wide range of observational datasets through data assimilation.

Relying on the two data sources, we create daily data on pressure, total precipitation, average temperature at 2 meters, and wind speed at 10 m above the earth's surface. These weather data are important to consider, given the extensive literature linking voting turnout with weather.
Relying on the two data sources, we create daily data on pressure, total precipitation, average temperature at 2 meters, and wind speed at 10 m above the earth's surface. These weather data are important to consider, given the extensive literature linking voting turnout with weather conditions (Knack 1994; Persson, Sundell and Öhrvall 2014; Damsbo-Svendsen and Hansen 2023).

3.4 Air Pollution Exposure Data, Treatment and Instrumental Variable

Using the latest advances in environmental sciences, we estimated daily data of air pollution average exposure for each municipality for the period 2013-2022 including several air pollutants: Particulate Matter less than 2.5 micrometers in mean aerodynamic diameter ($PM_{2.5}$), Particulate Matter less than 10 micrometers in mean aerodynamic diameter (PM_{10}), and Nitrogen Dioxide (NO_2). Our

[1] More information on these data is available at https://elezioni.interno.gov.it/ , last accessed February 2026.

methodology to estimate the concentration of each air pollutant in each municipality follows the procedure developed by ISPRA, the Italian Institute for Environmental Protection and Research.

To estimate daily average concentrations of $PM_{2.5}$, PM_{10}, and NO_2, at a 1 km × 1 km spatial resolution, we employed Bayesian hierarchical models, following the conceptual framework introduced by Clark and Gelfand (2006). This modelling strategy allows complex spatio-temporal processes to be represented through a structured hierarchy of simpler components, providing a flexible and coherent description of environmental variability.

Residual dependence across space and time was modeled using a Gaussian Random Field (GRF). The spatial component was defined through the Stochastic Partial Differential Equation (SPDE) approach, combined with a first-order autoregressive (AR1) process to represent temporal correlation (Lindgren et al., 2011). Inference was carried out using the Integrated Nested Laplace Approximation (INLA), building on the methodological framework proposed by Fioravanti et al. (2021). INLA offers a computationally efficient alternative to traditional Markov Chain Monte Carlo (MCMC) methods for latent Gaussian models and is implemented through the R-INLA package (http://www.r-inla.org).

Municipal-level estimates were then obtained by averaging the predicted concentrations across all 1 km × 1 km grid cells falling within each municipality.

In addition to the concentration of three air pollutants ($PM_{2.5}$, PM_{10}, and NO_2) on the date of the election for each municipality. From the daily data of air pollutants, we created several variables. Our main treatment variables are a set of variables representing the random increments of pollution in the air that are observed on the date of the election. We compute them as the difference between the average air pollutant concentration on the day of the election and the average of the n days before. Where n includes 10, 15, 30, and 60 days before the election. Further, we create for each air pollutant ($PM_{2.5}$, PM_{10}, and NO_2) a dummy equal to one if on the day of the election, the level of concentration of air pollutants is above the World Health Organization (WHO) daily limits contained in their Air Quality Guidelines (WHO Global Air Quality Guidelines, 2021). The WHO considers unsafe the daily concentration of $PM_{2.5}$ above 15 $\mu g/m^3$ 24-hour mean, PM_{10} above 45 $\mu g/m^3$ 24-hour mean, and NO_2 above 25 $\mu g/m^3$ 24-hour mean.

3.5 Individual Level Data

For the individual-level analysis, we use data from the ITANES (Italian National Election Studies) surveys for the 2013, 2018, and 2022 Italian general elections. These datasets provide detailed information on voters' political attitudes, electoral choices, and socio-demographic characteristics, allowing for a comparative analysis across three consecutive national elections.[2] A crucial requirement for our evaluation strategy is the identification of respondents' municipality of residence. This information is directly available only in the 2013 wave of the ITANES survey. In the 2018 and 2022 waves, the municipality is not explicitly reported; however, the dataset provides the province and a categorical variable indicating the population size of the municipality (e.g., in 2022, the population bins are: 0-5,000; 5,001-10,000; 10,001-30,000; 30,001-100,000; 100,001-250,000; and above 250,000 inhabitants). We exploit the fact that, in some provinces, only one municipality falls within a given population class. In such cases, we are able to uniquely identify the municipality of

[2] ITANES is a long-running academic research program coordinated by the Istituto Cattaneo and a network of Italian universities. It collects survey data before and after national elections to analyze voting behavior, political attitudes, party preferences, and socio-demographic characteristics of the Italian electorate. The ITANES surveys are widely used in political science research because they provide high-quality, comparable data across different election years. Data are freely accessible via: https://www.itanes.it/.

residence for respondents in the 2018 and 2022 waves as well. However, identification is not possible when multiple municipalities within the same province belong to the same population category. Overall, this procedure allows us to recover the municipality of residence for 65 percent (out of 5528) of respondents in 2018 and 61 percent (out of 6250) of respondents in 2022.

3.6 Summary Statistics

In Table 1, we provide summary statistics of the panel 2013-2022 to characterize the sample that we use in the empirical analysis at the municipal level. The descriptive statistics show substantial variation across political, socio-economic, weather, and air pollution variables. Voter turnout averages around 65%, displaying high variability (SD 13%), suggesting significant municipality differences. Socio-economic indicators such as the share of university graduates (mean 42.8%) and employment rate (mean 44.7%) appear moderately high but with some dispersion.

Table 1. Summary statistics municipality-level panel data 2013-2022

Variable Name	N	Min	Max	Mean	SD
Outcome Variable:					
Turnout (%)	61388	0.36	100	65.201	13.304
Socio-economic variables:					
Resident population	61388	31	2749031	7713.001	44675.021
University graduates (%)	61388	15.121	76.316	42.788	7.236
Employment rate (%)	61388	19.243	71.363	44.695	7.14
Weather variables:					
Daily pressure (hPa)	61388	70564.504	102707.587	96178.191	4543.59
Daily tot. precipitation (mm)	61388	0	118.87	5.311	9.093
Daily temperature (°C)	61388	-15.1	300.307	67.171	111.348
Daily wind speed (m/s)	61388	0.011	10.949	2.085	1.158
Air pollution variables:					
$PM_{2.5}$ (μg/m³)	61388	0	77.413	11.066	7.827
Day diff with previous 10day $PM_{2.5}$ (μg/m³)	61388	-41.298	44.687	-1.599	5.892
Day diff with previous 15day $PM_{2.5}$ (μg/m³)	61388	-32.06	49.652	-1.025	5.546
Day diff with previous 30day $PM_{2.5}$ (μg/m³)	61388	-32.16	49.263	-0.645	5.108
Day diff with previous 60day $PM_{2.5}$ (μg/m³)	61388	-42.768	55.139	-1.879	5.568
Over WHO AQG $PM_{2.5}$ (>15 μg/m³)	61388	0	1	0.181	0.385
PM_{10} (μg/m³)	61388	0	83.994	16.11	9.129
Day diff with previous 10day PM_{10} (μg/m³)	61388	-43.078	47.294	-2.679	7.361
Day diff with previous 15day PM_{10} (μg/m³)	61388	-36.469	49.340	-1.903	7.051
Day diff with previous 30day PM_{10} (μg/m³)	61388	-36.233	50.834	-1.498	6.756
Day diff with previous 60day PM_{10} (μg/m³)	61388	-39.556	54.418	-3.159	6.977
Over WHO AQG PM_{10} (>45 μg/m³)	61388	0	1	0.010	0.100
NO_2 (μg/m³)	61388	0	77.08	11.867	7.951
Day diff with previous 10day NO_2 (μg/m³)	61388	-29.787	23.933	-1.086	2.774
Day diff with previous 15day NO_2 (μg/m³)		-30.778	28.113	-1.016	3.015
Day diff with previous 30day NO_2 (μg/m³)	61388	-34.062	29.603	-1.187	3.189
Day diff with previous 60day NO_2 (μg/m³)	61388	-59.453	35.199	-1.763	3.869
Over WHO AQG NO_2 (>25 μg/m³)	61388	0	1	0.08	0.272

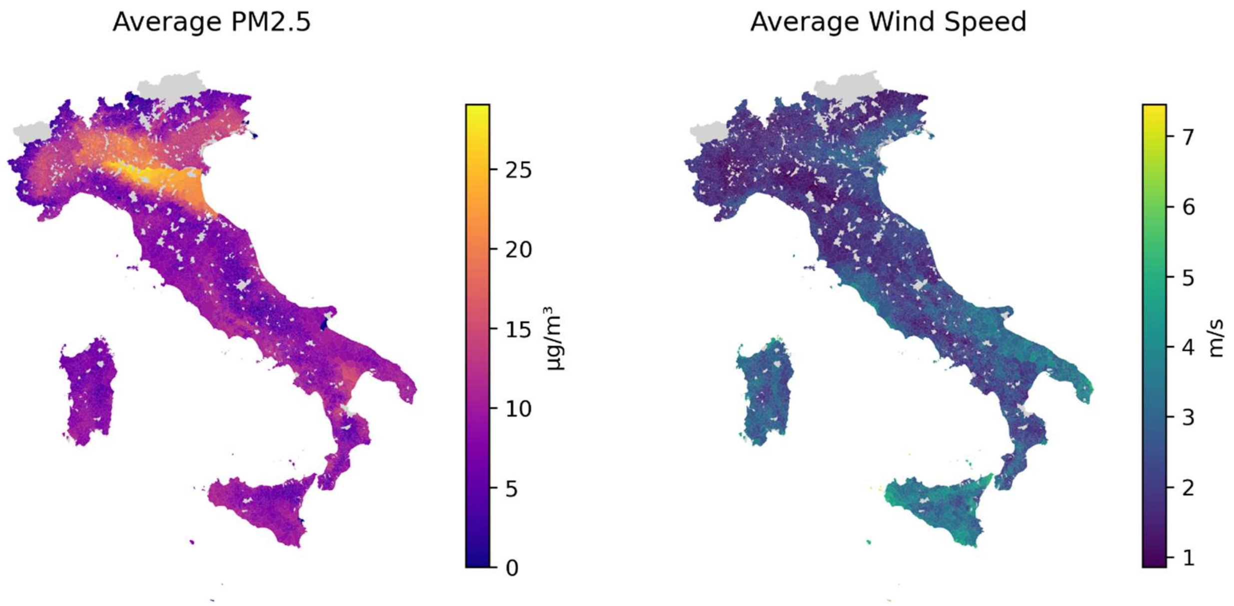
Notes: Electoral data are from the Ministry of the Interior, Socio-economic variables are from ISTAT, Weather data are from CERRA and kAIROS database, and Concentrations of pollutants come from ISPRA.

Weather conditions show a large variation, which is expected given the high seasonality of weather data. Air pollution levels are generally below WHO air quality guidelines on average (e.g., PM2.5 mean 11.1 µg/m³), though the binary "Over WHO AQG" indicators reveal that exceedances occur in roughly 18%, 45%, and 8% of cases for PM2.5, PM10, and NO_2, respectively.

Figure 1 shows the spatial distribution of $PM_{2.5}$ concentrations (left) and wind speed (right) across municipalities for the entire sample, showing the large variation in terms of exposure to air pollutants between municipalities and a negative relation between wind speed and air pollution.

Looking at the relation between turnout and exposure to air pollution, Figure A1 in the Appendix shows primary evidence of their relation. The figure shows, by election date, the mean change in $PM_{2.5}$ exposure on election day (day difference relative to the preceding 10-day $PM_{2.5}$ average, in µg/m³) and the mean electoral turnout. Shaded bands report 95 percent confidence intervals for the date-specific means. The series move inversely over time, providing suggestive descriptive evidence of a negative association between election-day $PM_{2.5}$ exposure and voter turnout.

Figure 1. Average $PM_{2.5}$ and Average Wind Speed in all municipalities



Notes: The left panel shows the average $PM_{2.5}$ across all observations in each municipality, while the right panel shows the average wind speed. Grey areas are municipalities for which data are not available and excluded from the analysis (i.e. the north-east is the autonomous region of the Valle d'Aosta, while on the top-right is the autonomous province of Bolzano)

Table 2 shows the summary statistics of the individual pre-electoral ITANES survey data. The reported mean intention to vote is 72%, which is consistent with the average Italian participation to the National elections in 2013 (75%), 2018 (73%), and 2022 (64%).

Table 2. Summary statistics of individual-level survey data pre-national elections 2013, 2018, and 2022

Variable Name	N	Min	Max	Mean	SD
Intention to Vote	5707	0	100	72.371	33.539
Socio-economic variables:					
Female	5707	1	2	1.523	0.5
Age	5707	18	119	49.863	15.941
Unemployed	5707	1	2	1.383	0.486
Political variables:					
Political disinterest	5707	1	3	2.285	0.679
Economics' future	5707	1	5	3.209	1.1
Views on immigration	5707	0	7	2.756	1.974
Views on Europe	5707	1	2	1.346	0.383
Weather variables:					
Daily pressure (hPa)	5707	85302.352	103501.047	99228.436	2297.52
Daily tot. precipitation (mm)	5707	0	95.408	2.717	6.943
Air pollution variables:					
Day diff with previous 10day $PM_{2.5}$ (μg/m³)	5707	-50.231	47.345	-0.349	7.974
Day diff with previous 15day $PM_{2.5}$ (μg/m³)	5707	-46,133	48,093	-0,607	7,731
Day diff with previous 30day $PM_{2.5}$ (μg/m³)	5707	-36,548	89,72	0,99	11,503
$PM_{2.5}$ (μg/m³)	5707	0.354	89.72	13.83	11.078
Over WHO AQG $PM_{2.5}$ (>15 μg/m³)	5707	0	1	0.273	0.446

Notes: Electoral data and Socio-economic data are from the ITANES survey for waves 2013, 2018, and 2022.Weather data are from CERRA and kAIROS database, and Air Pollution data come from ISPRA.

4. Identification Strategy

Our aim is to estimate the effect of short-run exposure to air pollutants on voting turnout. In the main analysis, we focus on the impact of fine particulate matter, $PM_{2.5}$, on electoral turnout, net of any potential confounding factors. We specify the relationship as follows:

$$Y_{mde} = \beta \ \Delta \text{PM2.5nday}_{\text{mde}} + X'_{mde}\gamma + \alpha_m + \alpha_d + \alpha_e + \epsilon_{mde} \qquad (1)$$

Where Y_{mde} is the voter turnout (%) in the municipality m on the election date d for election type e. Where e can correspond to national (Camera or European) or local (Regional, Municipality) elections.

Our main treatment variable is ΔPM2.5nday and is the difference between the $PM_{2.5}$ concentration on the election date and the average concentrations of the n previous days in the same municipality. The coefficient β captures the causal effect of short-term anomalies in $PM_{2.5}$ exposure on electoral participation. Focusing on changes rather than levels is particularly important, as air pollution exhibits pronounced seasonality; heating emissions during winter months, for example, tend to elevate baseline concentrations.

X'_{mde} is a vector of additional controls, including weather conditions on the election day and socio-economic characteristics of the municipality. Weather controls are particularly important, as $PM_{2.5}$ and other air pollutants are strongly influenced by meteorological factors that affect their dispersion and concentration. Moreover, specific weather conditions like the amount of precipitation are known to directly affect voting behavior (Damsbo-Svendsen and Hansen 2023). Accordingly, we include detailed controls for election-day weather, namely daily atmospheric pressure (hPa), total precipitation (mm), and temperature (°C).

The socioeconomic controls we include are the resident population, the share of university graduates, and the employment rate in each municipality over time. These variables serve to capture underlying demographic, educational, and economic characteristics that may systematically influence electoral participation. Population size is included to account for differences in urbanization and demographic composition, which can affect both the salience of local elections and the logistical costs of voting. Larger municipalities, for instance, often exhibit lower turnout rates due to higher voter anonymity, weaker social pressure to participate, and more complex administrative environments (Oliver, Shang and Callen 2012; Bolgherini and Mollisi 2024). The municipality's percentage of university graduates proxies for educational attainment, which has been consistently linked to political engagement and civic participation. More educated populations tend to have higher levels of political knowledge and stronger preferences for participating in the democratic process, leading to higher turnout (Tenn 2007; Gallego 2010).

Finally, the employment rate captures local economic conditions that may shape both political preferences and the opportunity cost of voting. Higher employment rates can indicate stronger local economic performance, which may either mobilize voters by increasing political efficacy or depress participation if economic satisfaction reduces perceived stakes (Gomez and Hansford, 2015; Kerwin Kofi, and Melvin; 2013). Controlling for these factors allows us to more precisely isolate the short-run effect of air pollution exposure from broader socioeconomic factors potentially influencing voting behavior.

We further include municipality, election date, and election type fixed effects to account for unobserved sources of heterogeneity that could confound the relationship between air pollution and voter turnout. Municipality fixed effects (α_m) absorb all time-invariant characteristics of each locality, such as persistent socioeconomic conditions, geographic features, or cultural and institutional factors influencing political participation. Election-date fixed effects (α_d) capture common shocks across municipalities that occur on a given election day—such as national political events, campaign intensity, or macroeconomic conditions—that might simultaneously affect both pollution levels and turnout. Election-type fixed effects (α_e) control for systematic differences across electoral contests, recognizing that national, regional, and local elections differ in salience, competitiveness, and expected participation. Together, these fixed effects ensure that the identification of β relies on within-municipality variation in $PM_{2.5}$ exposure across elections of the same type, net of any broader temporal or institutional influences.

We estimate the model sequentially, beginning with specifications that exclude and then include weather and socioeconomic controls, to assess the robustness of our findings to the inclusion of potential confounders. Our main specification, as defined in equation (1), incorporates the treatment variable (ΔPM2.5nday), which measures deviations in $PM_{2.5}$ concentrations on the election day relative to the average levels over the preceding 10, 15, 30, and 60 days. This approach allows us to evaluate the sensitivity of the estimated effects to alternative definitions of short-run exposure windows.

In additional analyses, we consider two complementary measures of pollution exposure. First, we construct an indicator variable equal to one if $PM_{2.5}$ concentrations on the election day exceed the World Health Organization's 24-hour air quality guideline. Second, we estimate the model using the observed $PM_{2.5}$ concentration on the election day itself.

In Appendix B, we repeat the same analysis using different air pollutants, particulate matter PM_{10} and NO_2.

4.1 Instrumental Variable

Despite the rich set of controls and fixed effects in equation (1), the estimated coefficient on short-run changes in $PM_{2.5}$ may still be subject to endogeneity concerns. In particular, local pollution levels can be affected by unobserved meteorological conditions that are imperfectly captured by our weather controls, by measurement error in monitoring data, and by behavioral responses that correlate with both air quality and turnout (e.g., differential scheduling of outdoor activities or campaign events). Such factors may bias OLS estimates of β, undermining a causal interpretation of the relationship between short-run exposure to $PM_{2.5}$ and electoral participation. To address these concerns, we complement our baseline specifications with an instrumental variable (IV) estimation that exploits the plausibly exogenous variation in pollution driven by the speed of wind on the election day.

Following Hunnicutt and Henderson (2023), we use election-day wind speed as an instrument for changes in $PM_{2.5}$ exposure ($\Delta \text{PM2.5nday}_{\text{mde}}$). The identifying intuition is that wind speed mechanically diffuses air pollutants and is therefore strongly negatively related to local $PM_{2.5}$ concentrations, while plausibly unrelated to other determinants of turnout once rich controls and fixed effects are included. Indeed, wind speed is a key driver of the dispersion of pollutants in the air; $PM_{2.5}$ typically falls as wind speed rises because stronger winds dilute and transport particles away, implying a strong negative correlation with fine particulate concentrations. At the same time, wind speed is plausibly orthogonal to the socioeconomic and political determinants of turnout, suggesting that exclusion restriction is respected. Unlike other meteorological variables such as precipitation or temperature, which may directly affect citizens' willingness or ability to go to the polls, the wind speed is not typically regarded as a salient cost of voting (Hunnicutt and Henderson, 2023) and is unlikely to influence participation except through its impact on air quality. Under this exclusion restriction hypothesis, wind speed provides a source of quasi-random variation in short-run $PM_{2.5}$ exposure, allowing us to purge $\Delta \text{PM2.5nday}_{\text{mde}}$ of its potential endogenous components.

Further, our analysis addresses three potential violations of the exclusion restriction. First, we control for a municipality's resident population, the percentage of university graduates, and the employment rate to proxy the municipality's urban development levels that vary over time. This might be the case because historic climatic conditions may be correlated with contemporary climatic conditions, urban development, and air pollution. Following this logic, for example, it might be plausible that windiest municipalities followed a unique development trajectory that both exposed their residents to lower levels of air pollution and created more conducive conditions for electoral participation. Second, we control for the municipality's precipitation and temperature levels on election day. This decision reflects how wind speed may simultaneously predict $PM_{2.5}$ concentrations and the onset of large storms (or heatwaves), which could deflate participation levels. Third, we further mitigate remaining concerns by including election-date fixed effects and municipality fixed effects. Election-date fixed effects absorb any nationwide shocks and common election-day conditions, like, for example, the occurrence of salient national events, the national economic conditions, media cycles, or countrywide weather patterns, that could jointly influence pollution and turnout. Municipality fixed effects, in turn, will absorb all time-invariant local characteristics, such as geography, long-run economic structure, baseline civic culture, persistent differences in infrastructure and service provision that might otherwise confound the relationship.

These controls ensure that identification is driven by idiosyncratic within-municipality variation in wind speed that predicts election day exposure to $PM_{2.5}$, rather than by broader weather systems or seasonal patterns that could directly influence turnout. Under this consideration, the IV estimates can be interpreted as capturing the causal effect of exposure to air pollution on turnout for the component of $PM_{2.5}$ variation induced by wind-driven dispersion.

We therefore estimate a two-stage least squares model in which we first regress $PM_{2.5}$ election-day changes in exposure on wind speed and the full set of controls and fixed effects, and then use the predicted values to identify the causal effect of short-run exposure to $PM_{2.5}$ on voter turnout.

We estimate the effect of $PM_{2.5}$ following an IV approach as follows. The first stage estimates:

$$\Delta\text{PM2.5nday}_{\text{mde}} = \beta\ \text{windspeed}_{\text{mde}} + X'_{mde}\gamma + \alpha_m + \alpha_d + \alpha_e + \epsilon_{mde} \quad (2)$$

Then, using the fitted values of municipality-level $PM_{2.5}$ changes from Equation 2 we estimate the second stage:

$$Y_{mde} = \beta\ \Delta\widehat{\text{PM2}}\text{.5nday}_{\text{mde}} + X'_{mde}\gamma + \alpha_m + \alpha_d + \alpha_e + \epsilon_{mde} \quad (3)$$

4.2 Investigating Individual-Level Mechanisms

As additional robustness, we complement our main municipality-level analysis, exploring a potential individual-level mechanism that might affect the relationship between exposure to air pollution and turnout, using available survey data. We should remark, though, that available survey data are collected only after the National elections for waves 2013, 2018, and 2022. For each wave, the data are collected on different survey dates, and both data coverage and survey questions differ substantially. As we described in Section 3.5, the 2013 data include the exact residential location of survey participants, whereas for 2018 and 2022, we inferred the location from the province of residence and municipality size. To estimate individual-level effects more precisely, additional data are needed both to examine elections in which the salience of air pollution may differ and to improve precision, since individual-level effects may be small and noisy, requiring a larger sample.

Besides data limitations, this robustness analysis aims to complement our main estimates and offers primary evidence of how exposure to $PM_{2.5}$ impacts electoral turnout at the individual level. Indeed, aggregate models capture how changes in pollution correlate with average turnout across municipalities and over time, but they cannot fully account for the fact that voting decisions are made by individuals whose perceptions, motivations, and constraints may differ substantially even within the same city.

In particular, the adverse effect of air pollution on voting turnout can be moderated by individuals' political interest. On the one hand, individuals with high political interest could perceive pollution as a salient policy failure and be better able to connect local air quality to governmental responsibility (Hunnicutt and Henderson, 2023); as a result, higher exposure could increase their voter turnout via issue-based mobilization or "grievance" voting. Conversely, individuals with lower political interest may be less likely to attribute pollution to political actors or to view voting as an effective response, making the turnout effect of pollution weaker or null. On the other hand, air pollution can create a crowding-out effect in individuals with high political interest. Since air pollution has short-term health effects, producing anxiety and depression that might reduce the perceived benefits of participating for individuals with higher political interest. Individuals with high political interest, who would otherwise be "reliable voters", may temporarily reallocate attention and effort away from electoral participation. By contrast, individuals who are less politically engaged already display low turnout intentions, leaving relatively little margin for air pollution to further depress their willingness to vote. Overall, an individual's political (dis-)interest plausibly conditions both the direction and magnitude of the pollution-turnout relationship by influencing the salience of air pollution as a policy failure, and the capacity and motivation to bear the short-term psychological and physical costs of participation.

Using survey data on citizens' intention to go to vote in the next election, matched with daily exposure to $PM_{2.5}$ concentrations at the survey date, we estimate a model that relates voting intentions to contemporaneous exposure to air pollution and respondents' political interest. This framework allows us to test whether political (dis-)interest moderates the effect of pollution on turnout intentions, and to explore whether adverse environmental conditions primarily discourage participation among politically engaged individuals. In doing so, we account for a rich set of individual characteristics, weather conditions, and municipality and date fixed effects, thereby isolating the role of air pollution and political engagement in shaping citizens' willingness to go to the polls.

We estimate the following model:

$$Y_{imd} = \beta\ \Delta\mathrm{PM2.5nday_{imd}} + \delta\ \Delta\mathrm{PM2.5nday_{imd}} X Political\ Disinterest_{imd} + \theta Political\ Disinterest_{imd} + X'_{imd}\gamma + \alpha_m + \alpha_d + \epsilon_{imd} \quad (4)$$

Where Y_{imd} is the probability that the individual *i,* resident in the municipality *m and* interviewed on day *d*, is willing to go to vote in the next election. Again, our main explanatory variable is $\Delta PM2.5\mathrm{nday}_{imd}$ which measures the exposure to $PM_{2.5}$ on the day the interview was conducted compared to baseline levels in preceding time-windows. *Political Disinterest* is a variable indicating how much individuals are interested in politics, where high values indicate lower interest. X'_{imd} are a set of individual-level control variables, including individuals' age, gender, unemployment, and opinions about the future of economics, immigration, and Europe. Further, we control for weather conditions, municipality fixed effects (α_m), and survey date fixed effects (α_d).

We have run the model of equation 4 without the interaction term, and the results are the same. Further, we have run an IV model similar to the one in section 4.1 using wind speed as an instrument for exposure to air pollution. In this case, the Wu-Hausman test for endogeneity is not statistically significant. This is not surprising, for each survey-election wave, individuals are interviewed on different dates. As a result, for each election wave, the same municipality is observed at multiple interview dates, and this generates additional exogenous variation in exposure to air pollution. We therefore use OLS as our preferred specification for inference.

5. Results

In this section, we discuss our main results examining the relation between exposure to air pollution on election day and electoral turnout at Italian municipalities.

Table 3 reports the estimates of equation (1), where the dependent variable is voter turnout (in percent). Where all specifications include municipality, election-date, and election-type fixed effects, as well as a comprehensive set of time-varying meteorological and socioeconomic controls. Across all specifications, we find a robust and statistically significant negative association between short-term deviations in $PM_{2.5}$ concentrations and electoral participation.

In columns (1)-(2), the coefficient of the difference between election-day $PM_{2.5}$ and the previous 10-day average indicates that a 10 microgram per cubic meter increase (μg/m³) in $PM_{2.5}$ on election day relative to the preceding 10-day average reduces turnout by approximately 1.7 to 1.9 percentage points. This implies that a spike in $PM_{2.5}$ on the election date (+10 μg/m³), which is nearly double the average $PM_{2.5}$ exposure and two standard deviations of the distribution of the variable, reduced the turnout by 3.1% on average, representing a loss of more than 920'000 voters. A loss that is about the population of Bergamo, the 5th most populous Italian city in 2026, and larger than the population of Palermo or Bologna.

The magnitude of the effect remains remarkably stable as we extend the exposure window. The results of the estimated coefficient of columns (3)-(5), respectively the 15-, 30-, and 60-day differences, show that a 10 microgram per cubic meter increase in election-day $PM_{2.5}$ decreases turnout by 1.6-2 percentage points, and all are statistically significant at the 0.1% level.

These results suggest that short-run increases in fine particulate matter systematically depress voter participation, with effects that are both economically and statistically meaningful.

Column (6) introduces a binary indicator for whether election day $PM_{2.5}$ concentrations exceed the WHO's 24-hour air quality guideline of 15 μg/m³. Although the coefficient is negative, it is not statistically distinguishable from zero, suggesting that the observed relationship is driven by continuous variation in pollution rather than by threshold exceedances alone. Finally, column (7) uses the contemporaneous election-day $PM_{2.5}$ concentration and yields a coefficient of -0.078. This implies that a 10 μg/m³ increase in election-day $PM_{2.5}$ reduces turnout by about 0.8 percentage points. The effect is significant at the 0.1% level, further corroborating the negative relationship between air pollution and voter turnout.

The results are robust to the use of alternative pollution measures. Appendix B reports estimates using PM_{10} concentrations (Table B1) and NO_2 concentrations (Table B2) as treatment variables. In both cases, the estimated coefficients remain negative and statistically significant, closely mirroring the magnitude and direction of the effects obtained for $PM_{2.5}$. These findings reinforce the conclusion that short-run exposure to ambient air pollution, regardless of pollutant type, is associated with lower electoral participation. Overall, the estimates are consistent with the hypothesis that acute exposure to air pollution reduces individuals' likelihood of voting, possibly through short-term health or psychological channels that increase the cost of electoral participation.

Table 3. The effect of $PM_{2.5}$ on turnout

	Dependent variable: Turnout (%)						
Day diff with previous 10day $PM_{2.5}$ (µg/m³)	-0.1672***	-0.1914***					
	(0.0085)	(0.0083)					
Day diff with previous 15day $PM_{2.5}$ (µg/m³)			-0.2036***				
			(0.0087)				
Day diff with previous 30day $PM_{2.5}$ (µg/m³)				-0.1729***			
				(0.0087)			
Day diff with previous 60day $PM_{2.5}$ (µg/m³)					-0.1602***		
					(0.0076)		
Over WHO AQG $PM_{2.5}$ (>15 µg/m³)						-0.1055	
						(0.1326)	
$PM_{2.5}$ (µg/m³)							-0.0783***
							(0.0079)
Controls:							
Municipalities FE	✓	✓	✓	✓	✓	✓	✓
Election Date FE	✓	✓	✓	✓	✓	✓	✓
Election Type FE	✓	✓	✓	✓	✓	✓	✓
Resident population		✓	✓	✓	✓	✓	✓
University graduates (%)		✓	✓	✓	✓	✓	✓
Employment rate (%)		✓	✓	✓	✓	✓	✓
Daily pressure (hPa)		✓	✓	✓	✓	✓	✓
Daily precipitation (mm)		✓	✓	✓	✓	✓	✓
Daily temperature (°C)		✓	✓	✓	✓	✓	✓
Observations	61388	61388	61388	61388	61388	61388	61388
N municipality	7210	7210	7210	7210	7210	7210	7210
R2	0.69992	0.70440	0.70466	0.70383	0.70404	0.70158	0.70218
Within R2	0.00725	0.02207	0.02294	0.02020	0.02088	0.01276	0.01474

Note: Municipality-level panel data fixed effect regression 2013-2022. Robust standard errors in parentheses are clustered at the level of municipalities. Significance codes are *** p < 0.001, ** p < 0.01, * p < 0.05.

As an additional robustness check, Table 4 presents fixed-effects IV estimates of equation (3), using the election day levels of wind speed as an instrument for exposure to $PM_{2.5}$ on election day, and the same panel structure and control set as before. The IV estimated coefficients are substantially larger in magnitude than the corresponding estimates in Table 3, implying that endogeneity likely biases the OLS estimates toward zero, suggesting a potential underestimation of the effect of $PM_{2.5}$ exposure on electoral participation. The diagnostics support instrument relevance and the presence of endogeneity. The first-stage F-statistics are comfortably above conventional weak-instrument thresholds, indicating strong instruments. Moreover, the Wu-Hausman tests reject exogeneity in each column, consistent with the view that the OLS estimates in Table 3 might understate the causal impact of pollution on turnout. The estimated effect of an increase in $PM_{2.5}$ exposure of 10 µg/m³ varies significantly between exposure windows and ranges from 19 to 2.9 percentage points decrease in turnout. However, we remain cautious as wind speed might be subject to high seasonality, and in the absence of data on industrial pollution sources and wind direction, the variable might imprecisely capture $PM_{2.5}$ exposure for a short window. Thus, our preferred models are the more conservative ones in columns (3)-(4), suggesting that a spike in $PM_{2.5}$ (10 µg/m³) on election day that doubles the average exposure reduces turnout of 3-4 percentage points. Relative to an average turnout of 65.2%, this amounts to a 4.6-6.1% decline, which, applied to roughly 46 million registered voters, implies a loss of about 1.4-1.8 million votes, corresponding to almost the entire population of Turin in 2026, the 4th largest Italian city.

Overall, the IV results strengthen the interpretation that short-run increases in $PM_{2.5}$ causally depress electoral participation, and they suggest the true effect may be materially larger than what standard FE models imply.

Table 4. The effect of $PM_{2.5}$ on turnout IV estimation

	Dependent variable: Turnout (%)					
Day diff with previous 10day $PM_{2.5}$ (µg/m³)	-1.991**					
	(0.7223)					
Day diff with previous 15day $PM_{2.5}$ (µg/m³)		-1.059***				
		(0.2912)				
Day diff with previous 30day $PM_{2.5}$ (µg/m³)			-0.4081***			
			(0.0992)			
Day diff with previous 60day $PM_{2.5}$ (µg/m³)				-0.2952***		
				(0.0707)		
Over WHO AQG $PM_{2.5}$ (>15 µg/m³)					-7.454***	
					(0.1854)	
$PM_{2.5}$ (µg/m³)						-0.2567***
						(0.0620)
Controls:						
Municipalities FE	✓	✓	✓	✓	✓	✓
Election Date FE	✓	✓	✓	✓	✓	✓
Election Type FE	✓	✓	✓	✓	✓	✓
Resident population	✓	✓	✓	✓	✓	✓
University graduates (%)	✓	✓	✓	✓	✓	✓
Employment rate (%)	✓	✓	✓	✓	✓	✓
Daily pressure (hPa)	✓	✓	✓	✓	✓	✓
Daily precipitation (mm)	✓	✓	✓	✓	✓	✓
Observations	61388	61388	61388	61388	61388	61388
N municipality	7210	7210	7210	7210	7210	7210
R2	0.44391	0.64578	0.69778	0.70078	0.68294	0.69903
Weak Instrument (N-Day diff $PM_{2.5}$) F-test (1st sage)	28.8***	106***	715.6***	1085.9***	393.9***	1115***
P-value	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000
Wu-Hausman	22.1***	18***	9.5890**	5.9445*	20.5***	8.91*
P-value	0.0000	0.0000	0.001	0.0148	0.0000	0.0028

Note: Municipality-level panel data fixed effect regression 2013-2022. Robust standard errors in parentheses are clustered at the level of municipalities. Significance codes are *** p < 0.001, ** p < 0.01, * p < 0.05.

5.1 Individual-Level Results

In this section, we explore the individual-level effect of exposure to air pollution on the intention to go to vote based on available survey data. Investigating the individual-level mechanism, we show how political disinterest moderates the relationship between air pollution and the intention to vote.

Table 5 presents the results of changes in exposure to $PM_{2.5}$ on the individual intention to go to vote. Across specifications, we confirm the adverse effect of exposure to air pollution on electoral participation. An increase of 10 µg/m³ in daily exposure to $PM_{2.5}$ decrease individual's intention to go to vote by between 2 and 3 percentage points. The overall estimates are aligned with our main municipal-level results presented in the main analysis. The estimates remain the same when the interaction term is not included.

Exploring the moderator effect of political (dis)interest, we find that the marginal effect of exposure to $PM_{2.5}$ on voting intentions becomes progressively less negative as political disinterest increases. Looking at our preferred specification in column (3), among respondents who are very interested in politics (category 1), a 10 µg/m³ increase in daily exposure to $PM_{2.5}$ is associated with a reduction in the intention to vote of 1.7 percentage points. For those who are fairly interested (category 2), the corresponding effect is close to zero (about -0.2 percentage points) and is positive (1.4 percentage points) for respondents who are little or not at all interested (category 3). A similar pattern emerges in the threshold specification (column 5), where we consider exposure as a dummy equal to one when $PM_{2.5}$ levels exceed the WHO guideline for air quality. In this case, the effect is larger on days when the air quality is poor; individuals with high political interest decrease their intention to go to vote by 4.6 percentage points, while individuals not interested in politics are more likely to go to the polls by 6 percentage points. In other words, more politically conscious individuals are depressed and discouraged by poor air quality, reducing their willingness to vote on polluted days, while less politically conscious individuals are more likely to go to the polls. Overall, these results indicate the presence of emotional reactions driven by exposure to air pollution that affect electoral participation.

However, survey data do not provide any psychological or emotional information; we are unable to test this directly. Theoretically, citizens who are otherwise politically engaged might react to air pollution with psychological disengagement, experiencing stress, anxiety, or fear that depresses their turnout intentions. In contrast, less politically engaged individuals might be more likely to experience anger or blame, increasing their willingness to vote. These differentiated reactions are aligned with the economic geography literature of electoral discontent, suggesting that emotions play a crucial role in shaping voting behaviors (Spicer, 2018; Rodríguez-Pose and Dijkstra, 2021; Lenzi and Perucca, 2021; Rodríguez-Pose et al., 2021).

Table 5. The effect of $PM_{2.5}$ on an individual's intention to go to vote

	Dependent variable:				
	Intention to Vote (0-100%)				
	(1)	(2)	(3)	(4)	(5)
Day diff with previous 10day $PM_{2.5}$ (µg/m³)	-0.226				
	(0.210)				
Day diff with previous 15day $PM_{2.5}$ (µg/m³)		-0.257			
		(0.212)			
Day diff with previous 30day $PM_{2.5}$ (µg/m³)			-0.333*		
			(0.143)		
$PM_{2.5}$ (µg/m³)				-0.450**	
				(0.145)	
Over WHO AQG $PM_{2.5}$ (>15 µg/m³)					-9.933**
					(3.671)
Political Disinterest	-10.105***	-10.085***	-10.408***	-12.679***	-11.604***
	(0.674)	(0.675)	(0.680)	(1.013)	(0.782)
Day diff with previous 10day $PM_{2.5}$ (µg/m³)X Political Disinterest	0.109				
	(0.083)				
Day diff with previous 15day $PM_{2.5}$ (µg/m³)X Political Disinterest		0.118			
		(0.085)			
Day diff with previous 30day $PM_{2.5}$ (µg/m³)X Political Disinterest			0.157**		
			(0.055)		
$PM_{2.5}$ (µg/m³) X Political Disinterest				0.187***	
				(0.055)	
Over WHO AQG $PM_{2.5}$ (>15 µg/m³) X Political Disinterest					5.316***
					(1.443)
Controls:					
Municipalities FE	✓	✓	✓	✓	✓
Survey Date FE	✓	✓	✓	✓	✓
Daily pressure (hPA)	✓	✓	✓	✓	✓
Daily precipitation (mm)	✓	✓	✓	✓	✓
Age	✓	✓	✓	✓	✓
Unemployed	✓	✓	✓	✓	✓
Female	✓	✓	✓	✓	✓
Views on economics' future	✓	✓	✓	✓	✓
Views on immigration	✓	✓	✓	✓	✓
Views on Europe	✓	✓	✓	✓	✓
Observations (individuals)	5,707	5,707	5,707	5,707	5,707
N Municipalities	201	201	201	201	201
R2	0.199	0.200	0.200	0.201	0.202
Adjusted R2	0.151	0.151	0.152	0.153	0.153

Note: Individual-level survey data post National elections 2013, 2018, and 2022. Robust standard errors in parentheses are clustered at the level of municipalities. Significance codes are *** $p < 0.001$, ** $p < 0.01$, * $p < 0.05$.

6. Conclusions

In this paper, we documented that short-run exposure to air pollution on election day reduces electoral participation in Italy. We find a stable negative effect between deviations in $PM_{2.5}$ concentrations on election day and turnout. A 10 µg/m³ increase in $PM_{2.5}$ on election day relative to baseline averages of preceding exposure windows lowers turnout by roughly 2-3 percentage points, which means that spikes in air pollution on election day, which double the average exposure, provoke a loss of almost 1 million voters, comparable to the population of a large Italian city like Bergamo or Turin. Importantly, the pattern is not pollutant-specific; estimates using PM_{10} and NO_2 remain negative and statistically significant, reinforcing the view that acute air-quality deterioration systematically depresses voting. Taken together, these findings indicate that temporary increases in air pollution can meaningfully raise the costs of participation and translate into lower electoral turnout, an externality of air pollution that extends beyond the previously known health (Deryugina et al., 2019) and productivity effects (He, Liu, and Salvo, 2019; Zivin and Neidell, 2012) Our results indicate that air pollution produces negative externalities that undermine the functioning of the democratic processes.

Finally, our individual-level evidence confirms that short-run exposure to air pollution depresses electoral participation at the individual level, consistently with our municipality-level estimates. Moreover, we find that political (dis)interest systematically moderates the response. Highly politically interested respondents show a pronounced decline in voting intentions when pollution rises, whereas those with low interest exhibit a muted or even positive response, especially on high-pollution days (when pollution exceeds the WHO guideline threshold). While we cannot directly observe emotional or psychological states, the results suggest heterogeneous emotional or motivational responses to poor air quality. The heterogeneity is consistent with differentiated emotional reactions, such as stress or discouragement among engaged citizens and anger or blame among the disengaged, linking air pollution to political behavior.

These findings, suggesting the potential role of emotions elicited by air pollution, speaks to the existing economic literature of political discontent and voting behavior that emphasize that negative emotions due to the negative consequences of globalization, automation, crises, or austerity reduce electoral turnout and increase protest or populist vote (Barone and Kreuter, 2021; Caselli, Fracasso and Traverso, 2020; Frey et al., 2018; Anelli, Colantone, and Stanig, 2019; Algan et al., 2017; Albanese, Barone, and De Blasio, 2022; Guiso et al., 2019, 2024) as well as economic-geography work linking "left-behind" places, industrial decline, and weakened community structures to political disengagement and populist votes (Spicer, 2018; Rodríguez-Pose and Dijkstra, 2021; Lenzi and Perucca, 2021; Rodríguez-Pose et al., 2021).

Future work should directly measure the emotional channels and better connect exposure to air pollutant sources, such as industrial emissions, to assess the institutional and accountability mechanisms that translate environmental harm into democratic outcomes at the micro-level. Besides its limitations due to the lack of micro-level geographical granularity and individual data, our work provides systematic evidence that exposure to poor air quality in municipalities reduces electoral participation with potentially uneven effects across individuals. Thus, our results raise concerns over environmental justice. Because pollution exposure is unevenly distributed across places and social groups, air quality may translate into unequal political voice. From a policy perspective, our findings suggest that air-quality regulation can have democratic benefits beyond well-known health effects. Overall, election management should treat extreme air pollution episodes as a barrier to electoral participation.

References

Anderson, M. L. (2020). As the wind blows: The effects of long-term exposure to air pollution on mortality. *Journal of the European Economic Association*, 18(4), 1886-1927.

Albanese, G., Barone, G., and De Blasio, G. (2022). Populist voting and losers' discontent: Does redistribution matter? *European Economic Review*, 141, 104000

Algan, Y., Guriev, S., Papaioannou, E., and Passari, E. (2017). The European Trust Crisis and the Rise of Populism. *Brookings Papers on Economic Activity* 2017(2), 309-400.

Anelli, M., Colantone, I., and Stanig, P. (2021). Individual vulnerability to industrial robot adoption increases support for the radical right. *Proceedings of the National Academy of Sciences*, 118(47), e2111611118

Autor, D., David D., Gordon H., and Kaveh M. (2020). Importing Political Polarization? The Electoral Consequences of Rising Trade Exposure. *American Economic Review*, 110 (10): 3139-83.

Barone, G. and H. Kreuter (2021). Low-wage import competition and populist backlash: The case of Italy. *European Journal of Political Economy*, 67, 101970.

Bellani, L., Ceolotto, S., Elsner, B., and Pestel, N. (2024). The political fallout of air pollution. *Proceedings of the National Academy of Sciences*, 121(18), e2314428121.

Bogaard, M., Künn, S., Palacios, J., and Pestel, N. (2024). *Polluted Job Search: The Impact of Poor Air Quality on Reservation Wages*. IZA - Institute for Labour Economics, Bonn. IZA Discussion Paper Series No. 17344 https://docs.iza.org/dp17344.pdf

Bolgherini, S., and Mollisi, V. (2024). Dissent is the word: New evidence on municipal turnout after amalgamation. *Political Geography*, 113, 103157.

Borgschulte, M., Molitor, D., and Zou, E. Y. (2024). Air pollution and the labor market: Evidence from wildfire smoke. *Review of Economics and Statistics*, 106(6), 1558-1575.

Caselli, M., Fracasso, A., and Traverso, S. (2020). Globalization and electoral outcomes: Evidence from Italy. *Economics & Politics*, 32(1), 68-103.

Charles, K. K., and Stephens Jr., M. (2013). Employment, wages, and voter turnout. *American Economic Journal: Applied Economics*, 5(4), 111-143.

Clark, J. S., & Gelfand, A. E. (Eds.). (2006). *Hierarchical modelling for the environmental sciences: Statistical methods and applications.* Oxford University Press.

Damsbo-Svendsen, S., and Hansen, K. M. (2023). When the election rains out and how bad weather excludes marginal voters from turning out. *Electoral Studies*, 81, 102573.

Deryugina, T., Heutel, G., Miller, N. H., Molitor, D., and Reif, J. (2019). The mortality and medical costs of air pollution: Evidence from changes in wind direction. *American Economic Review*, 109(12), 4178-4219.

Fioravanti, G., Martino, S., Cameletti, M., and Cattani, G. (2021). Spatio-temporal modelling of PM10 daily concentrations in Italy using the SPDE approach. *Atmospheric Environment*, 248, 118192.

Frey, C. B., Berger, T., and Chen, C. (2018). Political machinery: Did robots swing the 2016 US presidential election? *Oxford Review of Economic Policy*, 34(3), 418-442.

Gallego, A. (2010). Understanding unequal turnout: Education and voting in comparative perspective. *Electoral studies*, 29(2), 239-248.

Gomez, B. T., and Hansford, T. G. (2015). Economic Retrospection and the Calculus of Voting. *Political Behavior*, 37(2), 309-329.

Guiso, L., Herrera, H., Morelli, M., and Sonno, T. (2019). Global crises and populism: The role of Eurozone institutions. *Economic Policy*, 34(97), 95-139.

Guiso, L., Herrera, H., Morelli, M., and Sonno, T. (2024). Economic insecurity and the demand for populism in Europe. *Economica*, 91(362), 588-620.

He, J., Liu, H., and Salvo, A. (2019). Severe air pollution and labor productivity: Evidence from industrial towns in China. *American Economic Journal: Applied Economics*, 11(1), 173-201.

Herrnstadt, E., Heyes, A., Muehlegger, E., and Saberian, S. (2021). Air pollution and criminal activity: Microgeographic evidence from Chicago. *American Economic Journal: Applied Economics*, 13(4), 70-100.

Hoffmann, B., and Rud, J. P. (2024). The unequal effects of pollution on labor supply. *Econometrica*, 92(4), 1063-1096.

Hunnicutt, P., and Henderson, G. (2023). *Particulates Matter: Policy Failures, Air Pollution, and Collective Political Participation in the United States.* IGCC Working Paper No 14. escholarship.org/uc/item/51h8846s

Knack, S. (1994). Does rain help the Republicans? Theory and evidence on turnout and the vote. *Public Choice*, 79(1), 187-209.

Lavy, V., Ebenstein, A., and Roth, S. (2014). *The impact of short term exposure to ambient air pollution on cognitive performance and human capital formation* (No. w20648). National Bureau of Economic Research.

Lenzi, C., and Perucca, G. (2021). People or places that don't matter? Individual and contextual determinants of the geography of discontent. *Economic Geography*, 97(5), 415-445.

Lindgren, F., Rue, H., and Lindström, J. (2011). An explicit link between Gaussian fields and Gaussian Markov random fields: the stochastic partial differential equation approach. *Journal of the Royal Statistical Society Series B: Statistical Methodology*, 73(4), 423-498.

Persson, M., Sundell, A., and Öhrvall, R. (2014). Does Election Day weather affect voter turnout? Evidence from Swedish elections. *Electoral Studies*, 33, 335-342.

Pryor, J. T., Cowley, L. O., and Simonds, S. E. (2022). The physiological effects of air pollution: particulate matter, physiology and disease. *Frontiers in public health*, *10*, 882569.

Rodríguez-Pose, A., and Dijkstra, L. (2021). Does cohesion policy reduce EU discontent and euroscepticism? *Regional Studies*, 55(2), 354-369.

Rodríguez-Pose, A., Lee, N., and Lipp, C. (2021). Golfing with Trump. Social capital, decline, inequality, and the rise of populism in the US. *Cambridge Journal of Regions, Economy and Society*, 14(3), 457-481.

Spicer, J. S. (2018). Electoral systems, regional resentment and the surprising success of Anglo-American populism. *Cambridge Journal of Regions, Economy and Society*, 11(1), 115-141.

Stortini M, Arvani B, Deserti M. (2020). Operational Forecast and Daily Assessment of the Air Quality in Italy: A Copernicus-CAMS Downstream Service. *Atmosphere*. 11(5):447. https://doi.org/10.3390/atmos11050447

Tenn, S. (2007). The effect of education on voter turnout. *Political Analysis*, 15(4), 446-464.

Yu, W., Thurston, G., Shao, Y., Zhang, Y., Copeland, W. E., and Stein, C. R. (2025). Ambient air pollution and depressed mood in the National Longitudinal Study of Adolescent to Adult Health (Add Health) wave 4. *American journal of epidemiology*, 194(4), 975-983.

WHO Global Air Quality Guidelines (2021). *Particulate matter (PM 2.5 and PM 10), ozone, nitrogen dioxide, sulfur dioxide and carbon monoxide.* Geneva: World Health Organization; 2021. ISBN 978-92-4-003422-8.

Zivin, J. G., and Neidell, M. (2012). The impact of pollution on worker productivity. *American Economic Review*, 102(7), 3652-3673

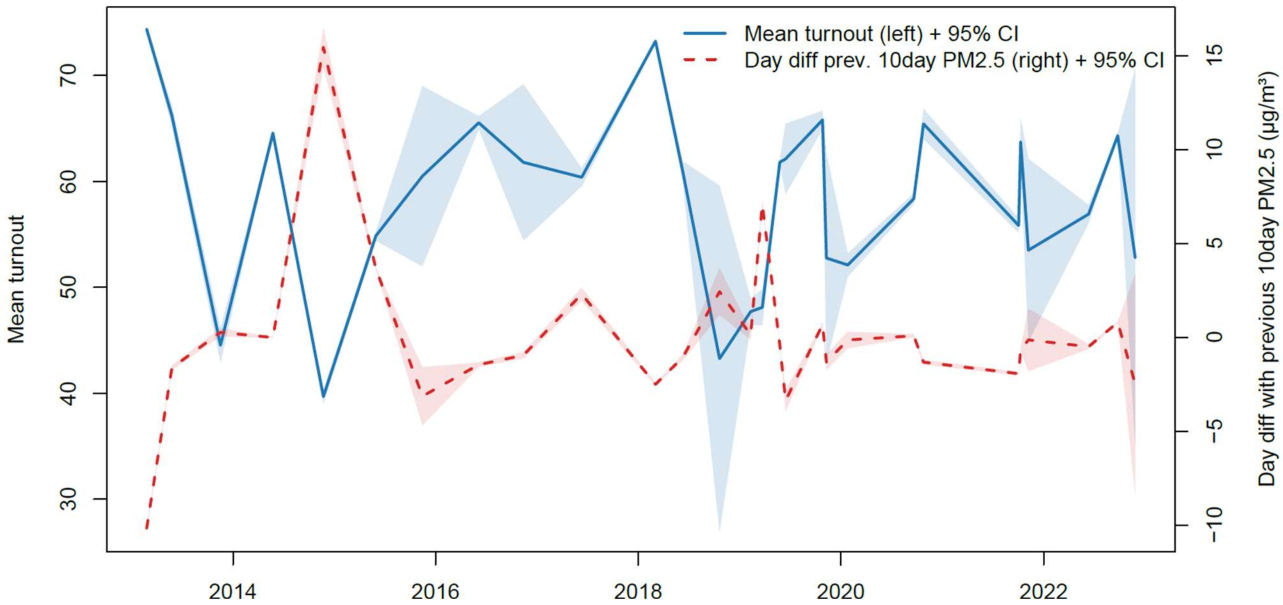
Appendix

A Electoral Data

Table A1. Election dates and number of municipalities voting per type of elections

Election Date	National Camera	Local Municipality	National European	Local Regional
2013-02-24	7210	0	0	1904
2013-05-26	0	521	0	0
2013-11-17	0	2	0	128
2014-05-25	0	3576	7210	1390
2014-10-26	0	1	0	0
2014-11-23	0	0	0	679
2015-05-31	0	641	0	2061
2015-11-15	0	3	0	0
2016-06-05	0	1203	0	0
2016-11-13	0	2	0	0
2017-06-11	0	794	0	0
2018-03-04	7210	0	0	1777
2018-06-10	0	578	0	0
2018-10-21	0	4	0	0
2019-02-10	0	0	0	288
2019-03-24	0	0	0	128
2019-05-26	0	3416	7210	1102
2019-06-16	0	27	0	0
2019-06-23	0	1	0	0
2019-07-07	0	1	0	0
2019-07-14	0	1	0	0
2019-10-27	0	0	0	86
2019-11-10	0	7	0	0
2020-01-26	0	0	0	679
2020-09-20	0	566	0	1265
2020-10-25	0	152	0	0
2021-10-03	0	1100	0	383
2021-10-10	0	91	0	0
2021-11-07	0	7	0	0
2022-06-12	0	772	0	0
2022-09-25	7210	0	0	0
2022-11-27	0	2	0	0

Figure A1. Mean voter turnout and changes in $PM_{2.5}$ concentrations by election date.



Notes: This figure plots election-date averages of voter turnout and changes in $PM_{2.5}$ exposure of election date on a common time axis. The solid line (left axis) shows the mean turnout across observations within each election date. The dashed line (right axis) shows the mean changes in $PM_{2.5}$ exposure (day difference relative to the preceding 10-day $PM_{2.5}$ average, in µg/m³) for the same election dates. Shaded areas denote 95 percent confidence intervals.

B Robustness with other Air Pollutants

Table B1. The effect of PM_{10} on turnout

	Dependent variable: Turnout (%)						
Day diff with previous 10day PM_{10} (µg/m³)	-0.1501***	-0.1696***					
	(0.0065)	(0.0064)					
Day diff with previous 15day PM_{10} (µg/m³)			-0.1813***				
			(0.0067)				
Day diff with previous 30day PM_{10} (µg/m³)				-0.1585***			
				(0.0066)			
Day diff with previous 60day PM_{10} (µg/m³)					-0.1448***		
					(0.0061)		
Over WHO AQG PM_{10} (>45 µg/m³)						-3.395***	
						(0.3714)	
PM_{10} (µg/m³)							-0.1031***
							(0.0066)
Controls:							
Municipality FE	✓	✓	✓	✓	✓	✓	✓
Election Date FE	✓	✓	✓	✓	✓	✓	✓
Election Type FE	✓	✓	✓	✓	✓	✓	✓
Resident population		✓	✓	✓	✓	✓	✓
University graduates (%)		✓	✓	✓	✓	✓	✓
Employment rate (%)		✓	✓	✓	✓	✓	✓
Daily pressure (hPa)		✓	✓	✓	✓	✓	✓
Daily precipitation (mm)		✓	✓	✓	✓	✓	✓
Daily temperature (°C)		✓	✓	✓	✓	✓	✓
Observations	61388	61388	61388	61388	61388	61388	61388
N municipality	7210	7210	7210	7210	7210	7210	7210
R2	0.69992	0.70579	0.70621	0.70487	0.70477	0.70202	0.70310
Within R2	0.00725	0.02667	0.02808	0.02365	0.02332	0.01419	0.01779

Note: Municipality-level panel data fixed effect regression 2013-2022. Robust standard errors in parentheses are clustered at the level of municipalities. Significance codes are *** $p < 0.0001$, ** $p < 0.001$, * $p < 0.01$.

Table B2. The effect of NO_2 on turnout

	Dependent Variable: Turnout (%)						
Day diff with previous 10day NO_2 (µg/m³)	-0.0549***	-0.0484***					
	(0.0123)	(0.0127)					
Day diff with previous 15day NO_2 (µg/m³)			-0.0683***				
			(0.0106)				
Day diff with previous 30day NO_2 (µg/m³)				-0.0392***			
				(0.0094)			
Day diff with previous 60day NO_2 (µg/m³)					-0.0413***		
					(0.0087)		
Over OMS AQG NO_2 (>25 µg/m³)						0.8941***	
						(0.1352)	
NO_2 (µg/m³)							0.0394***
							(0.0071)
Controls							
Municipality FE	✓	✓	✓	✓	✓	✓	✓
Election Date FE	✓	✓	✓	✓	✓	✓	✓
Election Type FE	✓	✓	✓	✓	✓	✓	✓
Resident population		✓	✓	✓	✓	✓	✓
University graduates (%)		✓	✓	✓	✓	✓	✓
Employment rate (%)		✓	✓	✓	✓	✓	✓
Daily pressure (hPa)		✓	✓	✓	✓	✓	✓
Daily tot. precipitation (mm)		✓	✓	✓	✓	✓	✓
Daily temperature (°C)		✓	✓	✓	✓	✓	✓
Observations	61388	61388	61388	61388	61388	61388	61388
N municipality	7210	7210	7210	7210	7210	7210	7210
R2	0.69782	0.70165	0.70175	0.70165	0.70168	0.70176	0.70171
Within R2	0.00030	0.01298	0.01332	0.01297	0.01308	0.01334	0.01319

Note: Municipality-level panel data fixed effect regression 2013-2022. Robust standard errors in parentheses are clustered at the level of municipalities. Significance codes are *** $p < 0.0001$, ** $p < 0.001$, * $p < 0.01$.

The UNU-MERIT WORKING Paper Series

2026-01 *Beyond Monetary Measures: Determinants of Multidimensional Poverty among Vulnerable Older Children and Youth in East Germany. A Perspective from Capability Approach and Capital Theory* by Charlotte Margarete Jost & Zina Nimeh

2026-02 *Sustainable urban rail integration: the case of the city of Maastricht* by Jo Coenen and Luc Soete

2026-03 *Redirect investment to stimulate the economy* by Huub Meijers and Joan Muysken

2026-04 *Airless democracy: Air pollution and voter turnout* by Giulia Rossello, Maria Antonietta Reatini, Gabriele Pinto, and Giorgio Cattani