Wildfire Smoke and Voting Behavior in the United States

Preliminary Results

David Clingingsmith
Case Western Reserve University

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Motivation

- Wildfire smoke is a very widespread *experiential* consequence of climate change in the U.S.
  - Unlike ambient air pollution, smoke events are visible, sudden, and directly attributable to wildfires — making them potentially more *salient* as climate signals
  - Tens of millions of Americans experience unhealthy air from wildfire smoke each year; awareness is high and rising
- Does smoke exposure change whether and how people vote?

Prior Work

- **Fire proximity** → pro-environment voting in CA, but only among Democrats (Hazlett and Mildenberger, 2020)
- **Overall air pollution (PM_{10})** → anti-incumbent voting in Germany (Bellani et al., 2024)
- **Rain on election day** → lower turnout (Gomez et al., 2007)

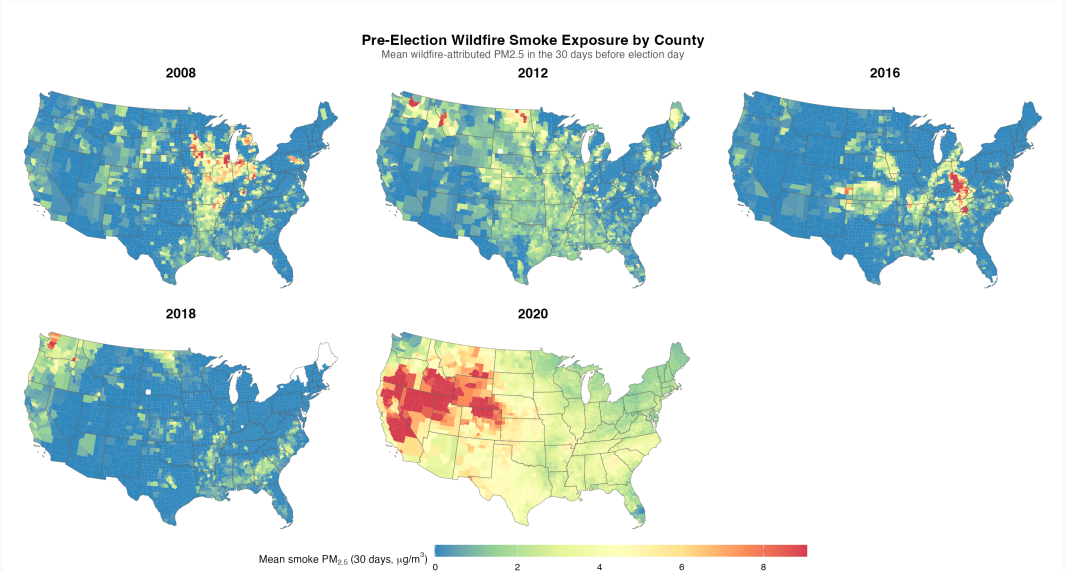
Gap: No study has linked wildfire-specific smoke $PM_{2.5}$ to U.S. election outcomes

- Smoke differs from generic air pollution: episodic, visible, attributable to a specific cause
- Smoke differs from fire proximity: affects far more people, plausibly exogenous (wind-driven), isolates the experiential channel from property destruction

Data

1. **Wildfire smoke $PM_{2.5}$** — Childs et al. (2022)
   - Daily, county-level, 2006–2020
   - Uses NOAA HMS satellite smoke plume classifications combined with machine learning to isolate wildfire-attributed $PM_{2.5}$ from background pollution
2. **Election returns** — MIT Election Data Lab (MIT Election Data + Science Lab, 2024)
   - Presidential: county-level (2008, 2012, 2016, 2020)
   - House: precinct-level returns aggregated to county (2016, 2018, 2020)
3. **Analysis samples:**
   - Presidential: 12,429 county $\times$ election obs (4 cycles)
   - House: 9,171 county $\times$ election obs (3 cycles)

Smoke Exposure Varies Dramatically Across Elections



Empirical Strategy

Two-way fixed effects:

$$Y_{ct} = \alpha_c + \gamma_t + \beta \cdot \text{SmokePM}_{ct} + \varepsilon_{ct}$$

- α_c: County FE — absorb all time-invariant confounders
- γ_t: Election year FE — absorb national swings
- SEs clustered by county
- Treatment: mean smoke $PM_{2.5}$ in the 60 days before election

Identifying assumption: Conditional on county and year FE, variation in smoke exposure is uncorrelated with unobserved determinants of voting. This is plausible because smoke plume direction is determined by wind, not by county politics or demographics.

Identification: Threats

Potential threats:

- Spatially correlated shocks (e.g., drought affects both fires and local economy)
  - Mitigated: smoke travels hundreds of miles from fire origin
- Secular trends in fire-prone vs. non-fire-prone regions
  - Mitigated: county FE absorb levels; year FE absorb national trends

TWFE with Continuous Treatment

Callaway et al. (2024) show TWFE with a continuous treatment can produce coefficients with ambiguous causal interpretation due to heterogeneous dose–response weighting.

Why this is less concerning here:

- Treatment is atmospherically assigned — limiting selection into dose levels
- We estimate a linear slope corresponding to the average causal response (ACRT) decomposition, in which weights are non-negative
- Robustness: results are qualitatively similar when treatment is dichotomized or discretized into dose bins

Main Results: Presidential and House Elections

	(1) DEM Vote Share	(2) Incumbent Share	(3) Log Turnout
Panel A: Presidential (2008–2020)			
Smoke $PM_{2.5}$ (60d)	0.00087***	−0.00399***	0.00242***
	(0.00009)	(0.00044)	(0.00018)
N	12,429	12,429	12,429
Panel B: County-Level House (2016–2020)			
Smoke $PM_{2.5}$ (60d)	0.00038***	−0.00153***	0.00177***
	(0.00013)	(0.00045)	(0.00066)
N	8,391	8,391	9,165

County and year FE. SEs clustered by county. *** $p < 0.01$.

Interpreting the Main Results

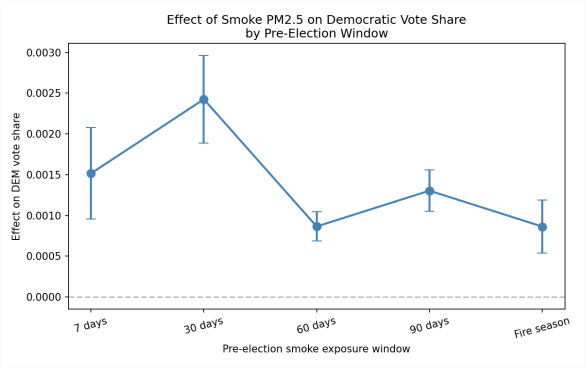
- **+10 μg/m^3 smoke $\rightarrow$ +0.9 pp DEM vote share** (presidential)
- Anti-incumbent effect is $\sim$4x larger than pro-DEM effect
- No evidence of turnout suppression
- House effects are present and significant, but smaller in magnitude — consistent with the more candidate-driven nature of House races

Effect Across the Partisan Spectrum

	DEM Vote Share		
	R-Leaning	Swing	D-Leaning
Smoke $PM_{2.5}$ (60d)	0.00066***	0.00049***	0.00082***
	(0.00021)	(0.00014)	(0.00013)
N	4,144	4,141	4,143

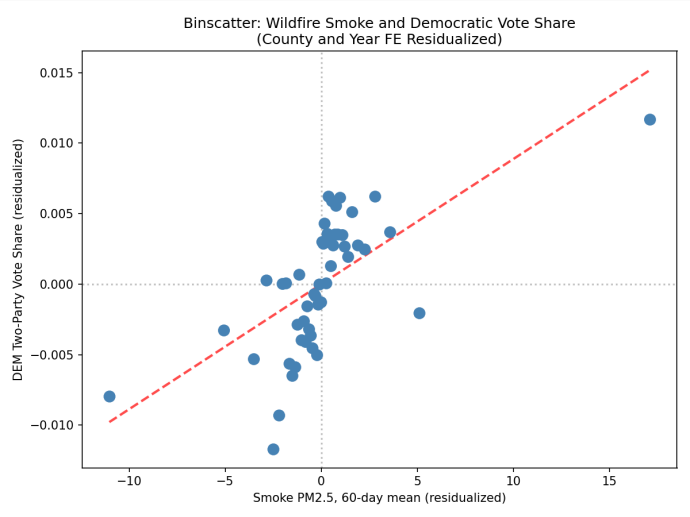
- Effect is **present in all terciles** of prior partisanship
- Somewhat larger in D-leaning counties
- Contrast with Hazlett and Mildenberger (2020): fire proximity affects *only* Democratic areas
- Smoke is a broader, less politically sorted treatment

Temporal Dynamics



- Effect significant at all windows
- Strongest at 30 days
- Consistent with recency / salience mechanism
- Not just election-day disruption

Binscatter: Smoke and Democratic Vote Share



County and year FE residualized. 50 equal-sized bins of smoke exposure.

Robustness: Excluding 2020

	Full Sample	Excluding 2020
Panel A: DEM Vote Share		
Smoke $PM_{2.5}$ (60d)	0.00087***	−0.00041
	(0.00009)	(0.00025)
Panel B: Incumbent Vote Share		
Smoke $PM_{2.5}$ (60d)	−0.00399***	−0.01446***
	(0.00044)	(0.00173)
Panel C: Log Total Votes		
Smoke $PM_{2.5}$ (60d)	0.00242***	0.00108***
	(0.00018)	(0.00028)
N	12,429	9,321

Interpreting the 2020 Sensitivity

- The pro-DEM effect is not robust to excluding 2020 — the extreme Western fire season provides much of the identifying variation
- The **anti-incumbent effect is robust and strengthens** without 2020 (-0.014 vs. -0.004), suggesting it is not an artifact of that single year
- The turnout effect attenuates but remains significant
- Incumbent punishment is the most robust finding across specifications

Limitations and Next Steps

Current limitations:

- Only 4 presidential elections; 3 House elections (smoke data: 2006–2020)
- Pro-DEM shift is leveraged by the 2020 fire season
- County-level aggregation; no individual-level variation
- Turnout measure is crude (log total votes without population denominator)

Planned extensions:

- NOAA HMS smoke plumes for extended coverage through 2024
- State legislative elections
- Wind direction as instrument for smoke exposure
- Conley spatial SEs for inference robust to spatial correlation

Summary

1. Wildfire smoke **punishes incumbents** — the most robust finding
2. Smoke also **shifts votes toward Democrats**, but this is driven by the 2020 fire season
3. Effects are **nationally representative** and **cross the partisan spectrum**
4. Smoke is **plausibly exogenous** (wind-driven) and affects **far more people** than fire proximity

References

Bellani, L., Ceolotto, S., Elsner, B., and Pestel, N. (2024). The effect of air pollution on voting behavior. *Proceedings of the National Academy of Sciences*, 121(18):e2309868121.

Callaway, B., Goodman-Bacon, A., and Sant'Anna, P. H. C. (2024). Difference-in-differences with a continuous treatment. *NBER Working Paper*, (32117). arXiv:2107.02637.

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