Environmental regulation, pollution, and shareholder wealth

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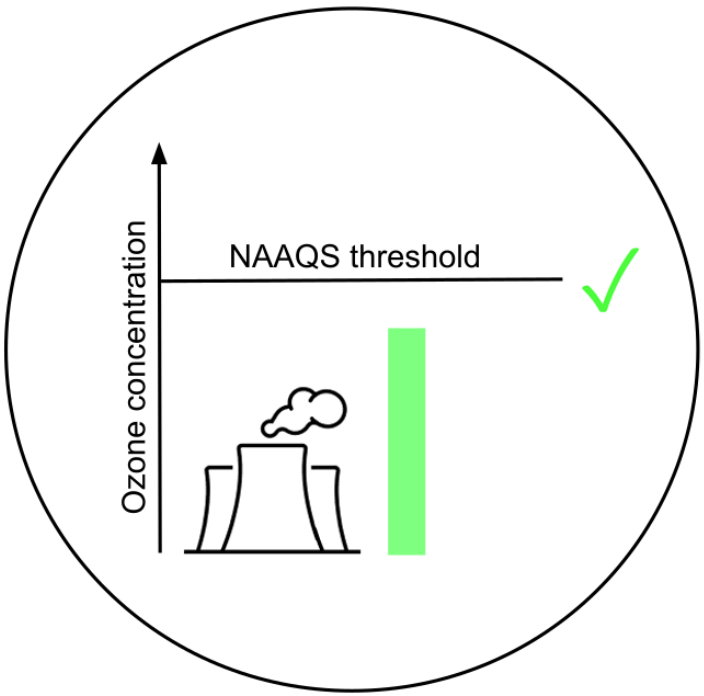
What is this paper about?

- How does the interplay between environmental regulations and firm pollution impact the financial stock market?
- Growing body of work on environmental regulations and financial markets.
- Affect pricing of:
  - Municipal bonds (Jha et al., 2020).
  - Corporate bonds (Seltzer et al., 2022).
  - Bank loans (Chen et al., 2023).
- This paper: Exploit local variation in federally-enforced legally binding regulation that has real effects on firms' polluting behavior to study stock market reactions.
- Key question: Does the stock market incorporate the consequences of local regulation on air pollution into the valuation of polluting firms?

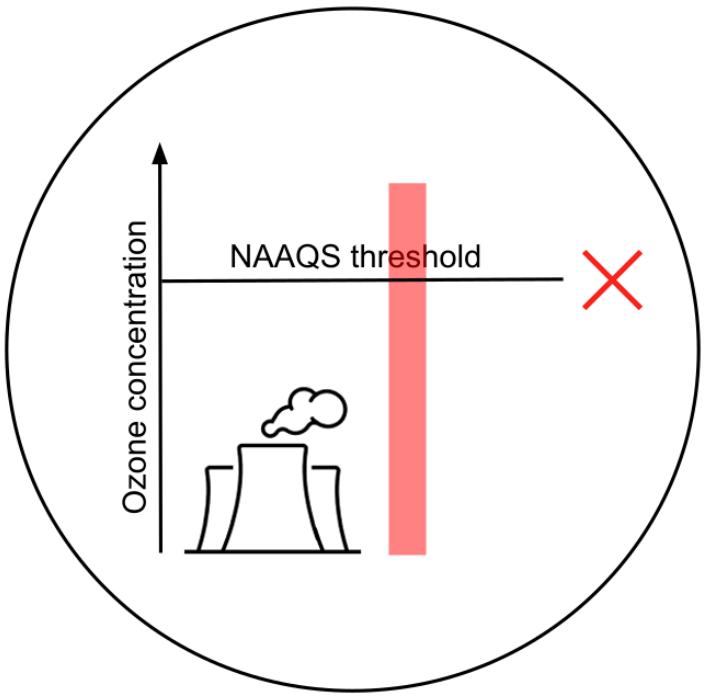
Nonattainment designations

Clean Air Act (CAA): National Ambient Air Quality Standards (NAAQS)

Attainment county



Nonattainment county



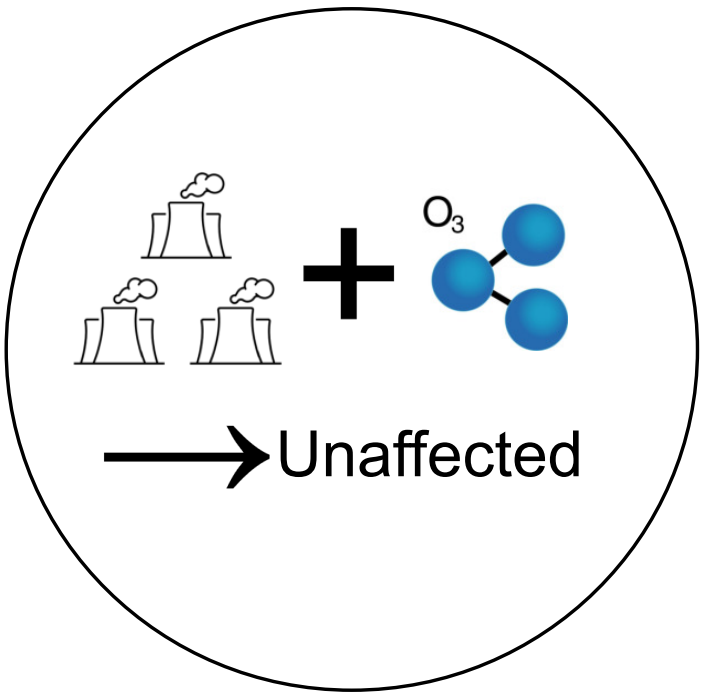
Implications for firms

- Stringent regulations and mandatory pollution abatement requirements.
- Nonattainment regulations are **binding** (Chay & Greenstone, 2003; Henderson, 1996; Greenstone, 2002).
  - Material impact on firms' emission behavior.
- Exogenous source of variation in **local** regulatory stringency $\rightarrow$ $\uparrow$ compliance costs.

Local variation in regulatory stringency

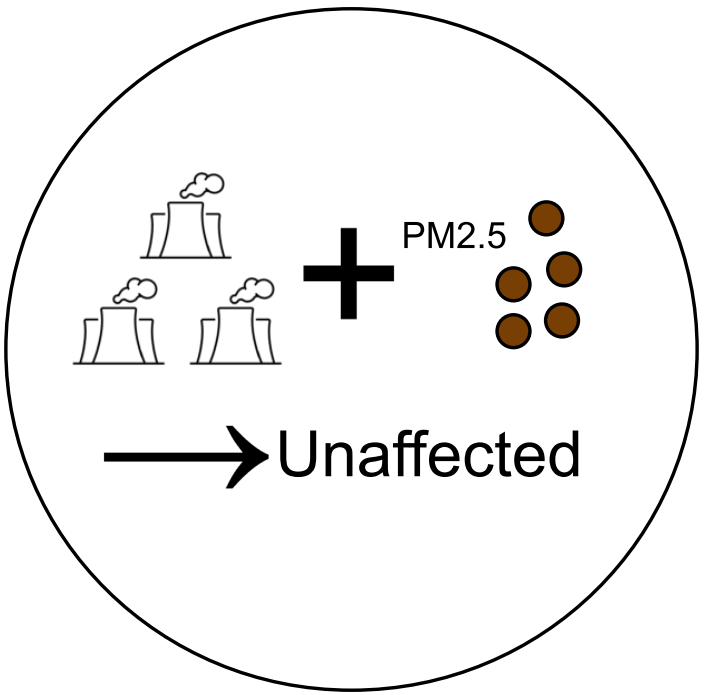
Not all polluting firms are regulated uniformly

Example 1: Attainment county



"Extensive margin"

Example 2: Nonattainment county



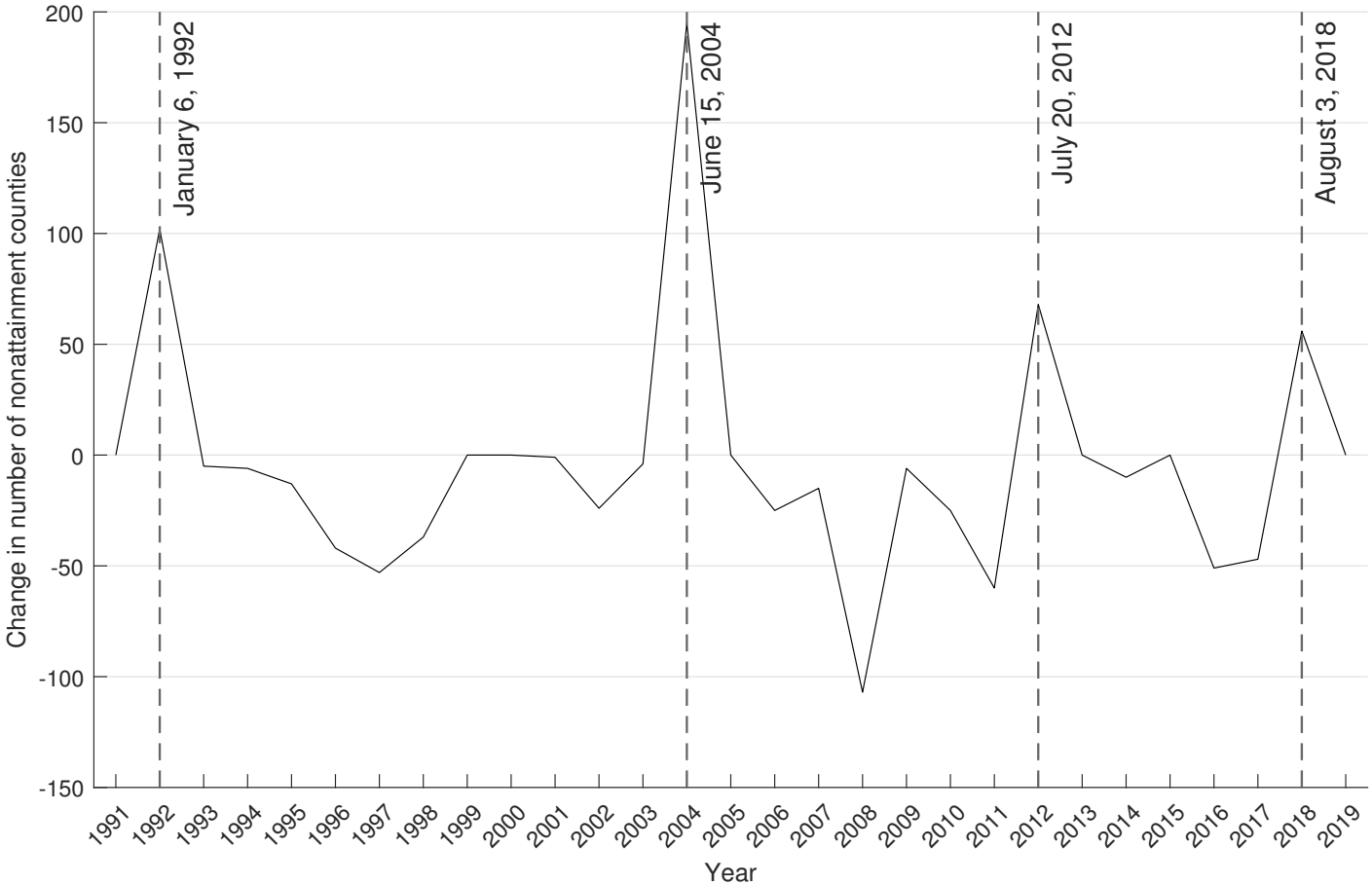
"Intensive margin"

Benefits and costs of regulation

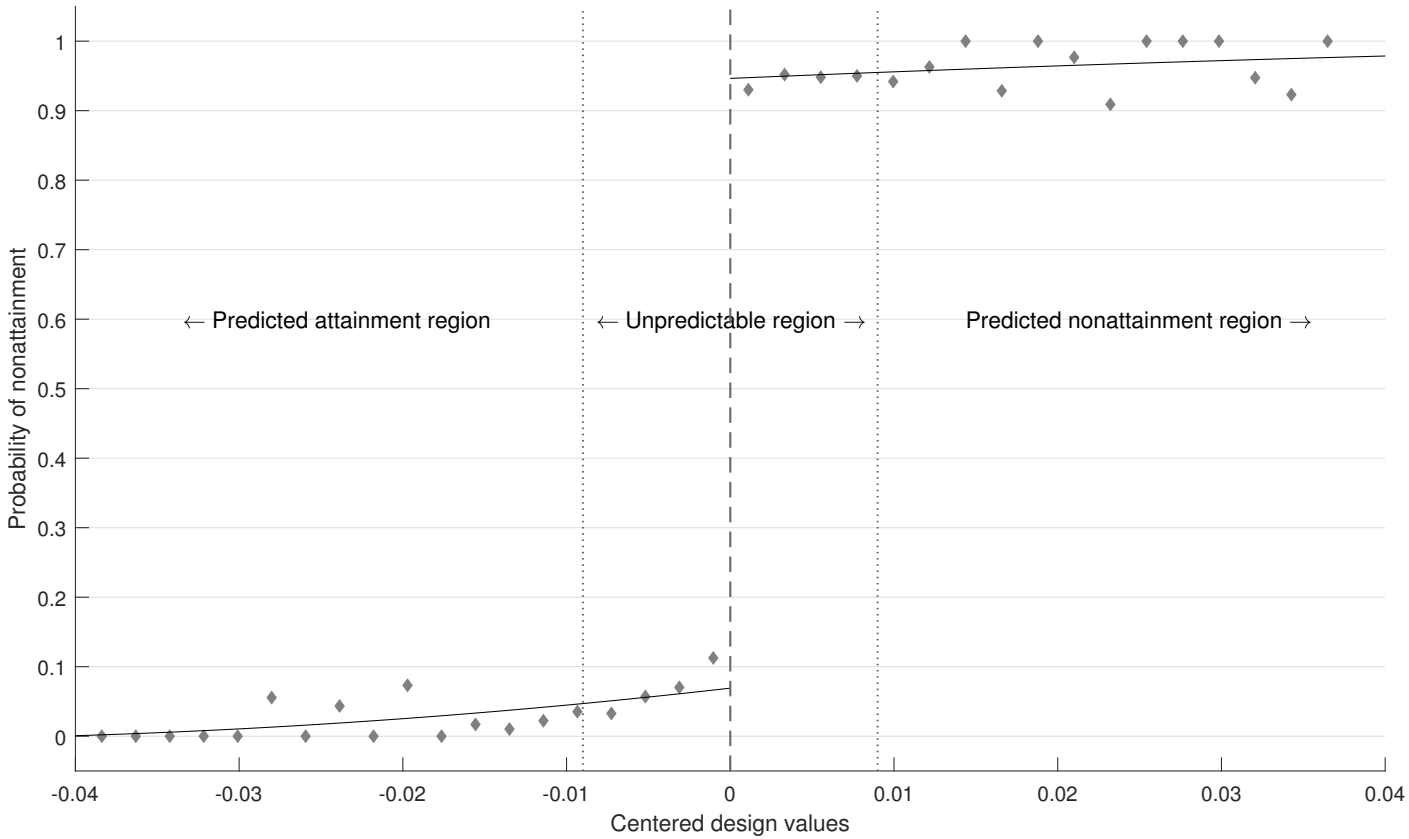
- **Competitive advantages for incumbent firms**:
  1. Barriers to entry.
     - Exit of polluting firms (Becker & Henderson, 2000; List et al., 2003, 2004).
     - Decreases competition among incumbent firms.
  2. "Grandfather" status.
     - Incumbents grandfathered from strictest regulations until they update or expand their operations.
     - $\rightarrow$ Operate at a cost advantage relative to new entrants.
- **Compliance costs**:
  - Devote some part of inputs to emissions reduction and pollution abatement.
    - Capital expenditures: LAER (nonattainment) vs BACT (attainment) (Becker & Henderson, 2000).
    - Adjustments to raw materials, maintenance practices (Becker & Henderson, 2001).
    - Emission offsets (Nelson et al., 1993; Shapiro & Walker, 2020).
  - Divert resources away from production $\rightarrow$ Hampering productivity $\rightarrow$ Downward revision in shareholders' beliefs.

Research design

- Nonattainment designations **induced** by discrete policy changes in the NAAQS threshold.



Decomposition of nonattainment designations



Key variable: *NA exposure*

- Plant-level pollution data: Hire chemistry PhD to **manually** map TRI chemicals into *ozone* and non-ozone pollutants.

$$NA\ exposure_{i,t} = \ln\left(1 + \sum_{j} ozone_{j,i,t-1} \cdot NA_{j,i,t}\right), \tag{1}$$

  for plant j, firm i, year t.

- $ozone_{j,i,t-1}$: total **amount** of ozone air emissions for plant j of firm i in year t.
- $NA_{j,i,t}$: dummy variable equal to one if plant j of firm i is located in a nonattainment county in year t, and zero otherwise.

$\Longrightarrow$ A *multi-plant firm* that operates many *heavy ozone-polluting* plants in nonattainment counties $\rightarrow$ **higher value** of *NA exposure*.

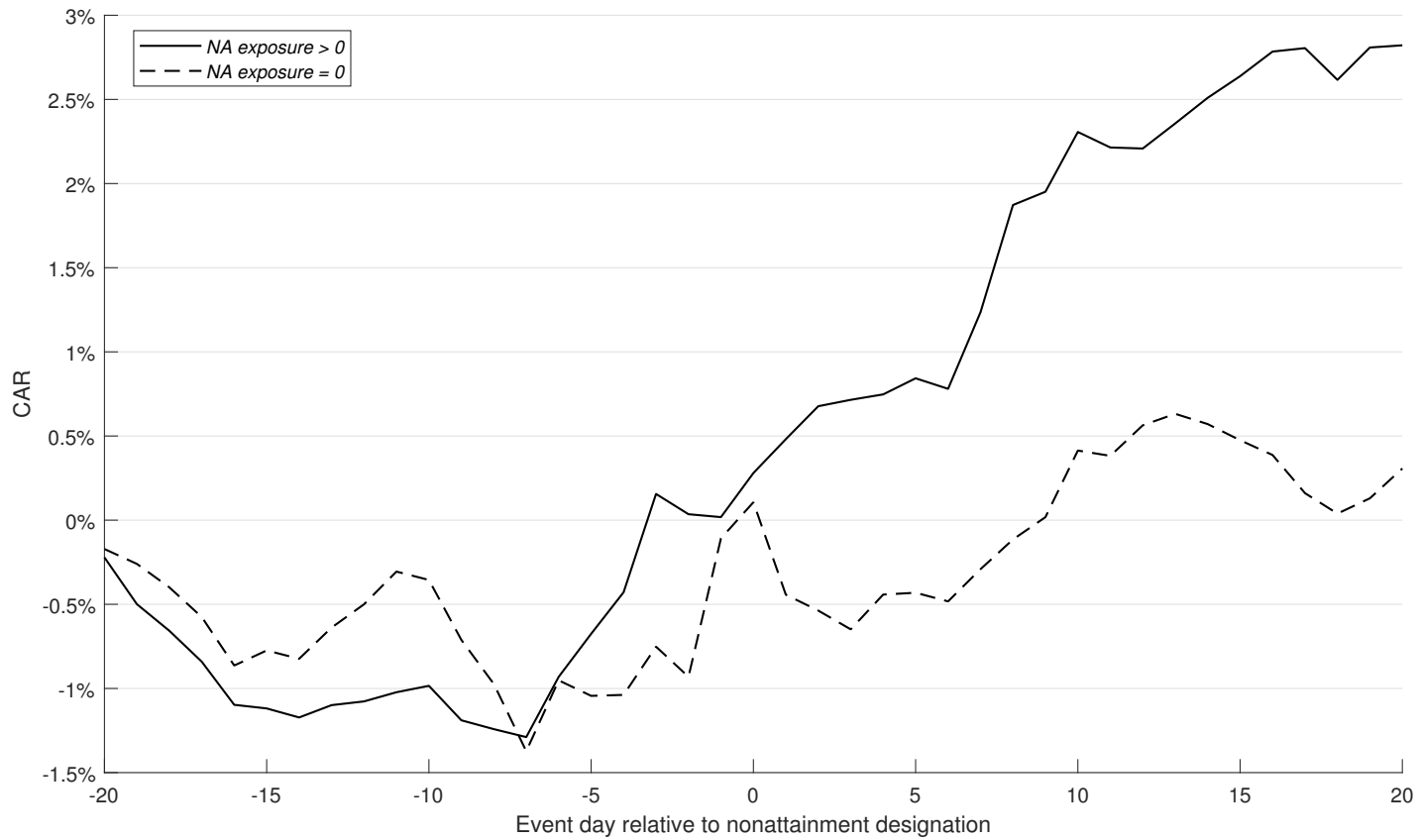
Unexpected and anticipated NA exposure

$$\textit{Unexp. NA exposure}_{i,t} = \ln\left(1 + \sum_j \textit{ozone}_{j,i,t-1} \cdot \textit{Unexp. NA}_{j,i,t}\right), \quad (2)$$

$$\textit{Antic. NA exposure}_{i,t} = \ln\left(1 + \sum_j \textit{ozone}_{j,i,t-1} \cdot \textit{Antic. NA}_{j,i,t}\right), \quad (3)$$

$\textit{Unexp. NA}_{j,i,t}$ ($\textit{Antic. NA}_{j,i,t}$) is a dummy variable equal to one if plant j of firm i is located in an unexpected (anticipated) nonattainment county in year t, and zero otherwise.

CARs around nonattainment designation



Economic magnitude

- Average gain: \$107 million (1.215% $\times$ \$8.84 billion) over the 11-day window.

Panel A: Full sample

	NA exposure > 0 ($N = 1,106$)		*NA exposure* $= 0$ ($N = 1,442$)		Difference: *NA exposure* > 0 vs. *NA exposure* $= 0$	
	Mean	Median	Mean	Median	Mean	Median
Event window	(1)	(2)	(3)	(4)	(5)	(6)
$(-2, +2)$	0.449*	0.359***	-0.536***	-0.913***	0.985***	1.271***
	(1.74)	(2.58)	(-2.83)	(-3.18)	(3.08)	(3.41)
$(-5, +5)$	1.157***	1.143***	-0.057	0.284	1.215***	0.860**
	(3.83)	(3.03)	(-0.33)	(0.74)	(3.47)	(2.06)

Panel B: Decomposition

	Unexpected ($N = 722$)		Anticipated ($N = 383$)		Difference: Unexpected vs. *NA exposure* $= 0$		Difference: Anticipated vs. *NA exposure* $= 0$	
	Mean	Median	Mean	Median	Mean	Median	Mean	Median
Event window	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)
$(-2, +2)$	0.479*	0.346**	-0.351	-0.006	1.015***	1.259**	0.184	0.906
	(1.79)	(2.53)	(-0.75)	(-0.01)	(2.90)	(2.89)	(0.38)	(1.28)
$(-5, +5)$	1.189***	1.143**	0.242	-0.793	1.246***	0.860**	0.299	-1.076
	(3.64)	(2.01)	(0.54)	(-0.90)	(3.19)	(1.96)	(0.62)	(-1.53)

Cross-sectional regression of nonattainment CARs

- Competitive advantages gradually erode due to the rising compliance costs.

Dep. variable:	CAR $(-2, +2)$				CAR $(-5, +5)$			
	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)
NA exposure	0.281**		0.477***		0.365***		0.574***	
	(2.35)		(3.07)		(2.98)		(3.00)	
NA exposure^2	-0.025**		-0.043***		-0.033***		-0.054***	
	(-2.36)		(-3.18)		(-3.13)		(-3.16)	
Unexp. NA exposure		0.342***		0.503***		0.543***		0.674**
		(2.71)		(3.24)		(2.88)		(2.57)
Unexp. NA exposure^2		-0.030***		-0.042***		-0.052***		-0.066***
		(-2.63)		(-3.02)		(-3.03)		(-2.63)
Antic. NA exposure		-0.128		-0.122		0.021		-0.285
		(-1.23)		(-0.83)		(0.13)		(-1.36)
Antic. NA exposure^2		0.015		0.012		-0.002		0.022
		(1.60)		(0.92)		(-0.10)		(1.26)
F-statistic	2.82	3.67	5.08	5.27	4.88	4.62	5.02	3.46
p-value	0.059	0.026	0.007	0.005	0.008	0.010	0.007	0.03
Controls	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes
Year F.E.	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes
Industry F.E.	Yes	Yes	No	No	Yes	Yes	No	No
Firm F.E.	No	No	Yes	Yes	No	No	Yes	Yes
Observations	2,027	2,027	1,538	1,538	2,026	2,026	1,530	1,530
Adj R^2	0.10	0.10	0.07	0.07	0.11	0.11	0.09	0.09

Cross-sectional regression of attainment redesignation CARs

- Opposite results when we consider redesignations back to attainment.

Dep. variable:	CAR $(-2,+2)$				CAR $(-5,+5)$			
	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)
Redesig exposure	-0.168**		-0.137*		-0.290***		-0.273**	
	(-2.68)		(-1.78)		(-3.32)		(-2.37)	
Redesig exposure^2	0.017**		0.015*		0.031***		0.030**	
	(2.36)		(1.80)		(3.88)		(2.59)	
Unexp. redesig exposure		-0.183**		-0.232**		-0.334**		-0.443***
		(-2.41)		(-2.44)		(-2.59)		(-3.12)
Unexp. redesig exposure^2		0.020**		0.025**		0.033**		0.044***
		(2.47)		(2.62)		(2.52)		(2.89)
Antic. redesig exposure		-0.025		-0.028		0.107		0.141
		(-0.25)		(-0.27)		(0.91)		(0.89)
Antic. redesig exposure^2		0.004		0.003		-0.011		-0.011
		(0.39)		(0.28)		(-0.93)		(-0.67)
F-statistic	3.84	3.09	1.65	3.63	7.51	3.37	3.44	4.90
p-value	0.035	0.063	0.213	0.041	0.003	0.050	0.048	0.016
Controls	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes
Year F.E.	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes
Industry F.E.	Yes	Yes	No	No	Yes	Yes	No	No
Firm F.E.	No	No	Yes	Yes	No	No	Yes	Yes
Observations	4,513	4,513	4,428	4,428	4,512	4,512	4,427	4,427
Adj R^2	0.10	0.09	0.13	0.10	0.09	0.06	0.14	0.13

New entrants

- A nonattainment designation for a county leads to an 11% decrease in the expected number of new TRI plants in the subsequent year.

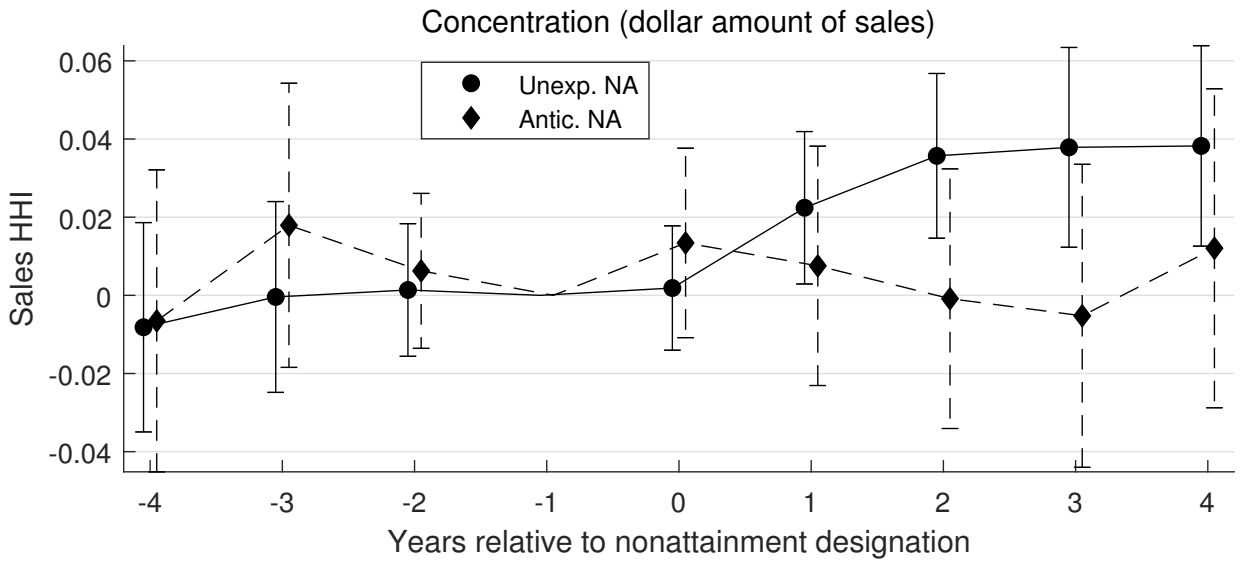
Dep. variable: *Plant births*$_t$	(1)	(2)	(3)	(4)
NA_{t-1}	-0.131***	-0.121***		
	(-10.79)	(-6.14)		
Unexp. NA_{t-1}			-0.340***	-0.334***
			(-3.20)	(-9.30)
Antic. NA_{t-1}			0.039	0.044
			(0.41)	(0.99)
Controls	No	Yes	No	Yes
Year × Cohort F.E.	Yes	Yes	Yes	Yes
County × Cohort F.E.	Yes	Yes	Yes	Yes
Log likelihood	-8,101.5	-6,791.8	-8,093.4	-6,784.0
Observations	17,746	14,017	17,746	14,017
Pseudo R^2	0.12	0.12	0.12	0.12

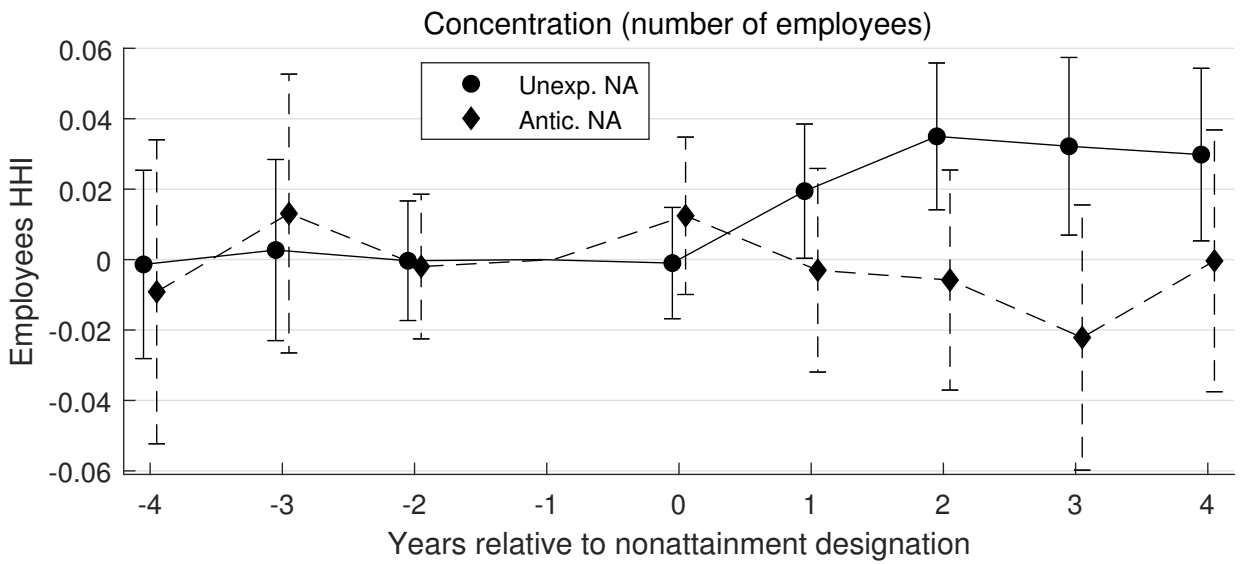
County-level competition

- Stacked DiD at the county-level. $(-4, +4)$ years window.
- 4.6% increase in sales concentration among ozone-emitting plants in unexpected nonattainment counties, relative to the sample mean, in comparison to always-attainment counties.

Dep. variable:	*Sales HHI*		*Employees HHI*	
	(1)	(2)	(3)	(4)
NA × *Post*	0.021***		0.018***	
	(2.84)		(2.39)	
Unexp. NA × *Post*		0.028***		0.023***
		(3.13)		(2.64)
Antic. NA × *Post*		0.002		0.002
		(0.11)		(0.12)
Year × Cohort F.E.	Yes	Yes	Yes	Yes
County × Cohort F.E.	Yes	Yes	Yes	Yes
Observations	23,677	23,677	23,677	23,677
Adj R^2	0.75	0.75	0.76	0.76

Dynamic effects





Firm-level competition: Product market

- Stacked DiD at the firm-level with continuous treatment. $(-4, +4)$ years window.
- $\uparrow$ *Fluidity*, $\uparrow$ *Similarity* $\rightarrow \uparrow$ Competitive threat for the firm due to increased product-relatedness to competitors.

Dep. variable:	*Fluidity*		*Similarity*	
	(1)	(2)	(3)	(4)
NA exposure × *Post*	-0.020**		-0.020*	
	(-1.97)		(-1.72)	
Unexp. NA exposure × *Post*		-0.087***		-0.031***
		(-3.07)		(-6.39)
Antic. NA exposure × *Post*		0.001		0.010
		(0.14)		(1.64)
Controls	Yes	Yes	Yes	Yes
Year × Cohort F.E.	Yes	Yes	Yes	Yes
Firm × Cohort F.E.	Yes	Yes	Yes	Yes
Observations	13,929	13,929	14,385	14,385
Adj R^2	0.66	0.66	0.62	0.62

Firm-level competition: Supply chain contracting

Dep. variable:	Full sample				8-Hour Ozone (2008) sample					
	Number of new contracts		*Number of new customers*		*Number of new contracts*		*Number of new customers*		*Contract length (days)*	
	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)	(9)	(10)
NA exposure × *Post*	0.073**		0.067**		0.140**		0.143**		8.784**	
	(1.99)		(1.99)		(2.01)		(2.08)		(2.32)	
Unexp. NA exposure × *Post*		0.153**		0.141***		0.306**		0.310**		41.622**
		(2.76)		(2.98)		(2.38)		(2.44)		(3.06)
Antic. NA exposure × *Post*		0.040		0.045		0.084		0.080		3.396
		(0.61)		(0.75)		(0.47)		(0.46)		(0.45)
Controls	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes
Year × Cohort F.E.	Yes	Yes	Yes	Yes	No	No	No	No	No	No
Firm × Cohort F.E.	Yes	Yes	Yes	Yes	No	No	No	No	No	No
Year F.E.	No	No	No	No	Yes	Yes	Yes	Yes	Yes	Yes
Firm F.E.	No	No	No	No	Yes	Yes	Yes	Yes	Yes	Yes
Observations	8,525	8,525	8,525	8,525	3,368	3,368	3,368	3,368	3,368	3,368
Adj R^2	0.33	0.33	0.33	0.33	0.26	0.26	0.26	0.26	0.17	0.17

Facility-level compliance costs

- Stacked DiD at the facility-level. $(-4, +4)$ years window.
- Proxy for potential compliance costs with observable regulatory enforcement and source reduction activities.

Panel A: Regulatory enforcement

Dep. variable:	*HPV*		*Title V inspection*		*Compliance evaluation*	
	(1)	(2)	(3)	(4)	(5)	(6)
Facility NA exposure × *Post*	0.001**		0.003***		0.001**	
	(2.23)		(5.78)		(2.36)	
Facility Unexp. NA exposure × *Post*		0.001**		0.004***		0.002***
		(2.32)		(6.22)		(2.75)
Facility Antic. NA exposure × *Post*		0.000		0.000		0.001
		(0.48)		(0.52)		(0.81)
Year × Cohort F.E.	Yes	Yes	Yes	Yes	Yes	Yes
Plant × Cohort F.E.	Yes	Yes	Yes	Yes	Yes	Yes
Observations	126,363	126,363	126,363	126,363	126,363	126,363
Adj R^2	0.18	0.18	0.82	0.82	0.54	0.54

Panel B: Source reduction

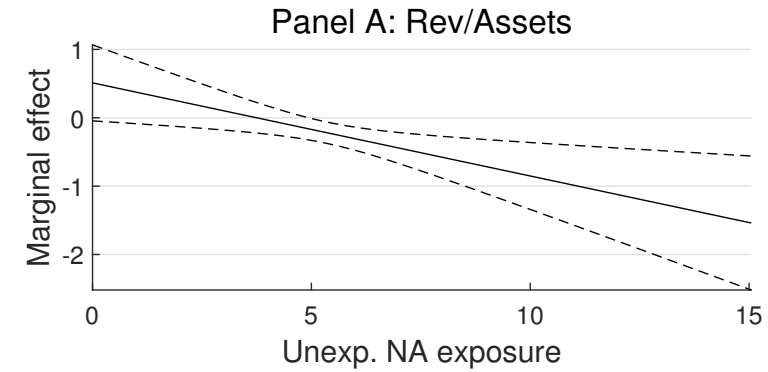
Dep. variable:	*Onsite treated*		*Onsite recovery*		*Onsite recycle*		*SR activity*	
	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)
Facility NA exposure × *Post*	0.063***		0.010**		0.041***		0.007***	
	(9.52)		(2.48)		(7.56)		(10.50)	
Facility Unexp. NA exposure × *Post*		0.081**		0.025***		0.049**		0.010**
		(2.53)		(2.60)		(2.14)		(2.10)
Facility Antic. NA exposure × *Post*		0.018		0.004		0.025		0.002
		(1.26)		(0.96)		(1.59)		(0.73)
Year × Cohort F.E.	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes
Plant × Cohort F.E.	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes
Observations	126,363	126,363	126,363	126,363	126,363	126,363	126,363	126,363
Adj R^2	0.87	0.87	0.80	0.80	0.74	0.74	0.46	0.46

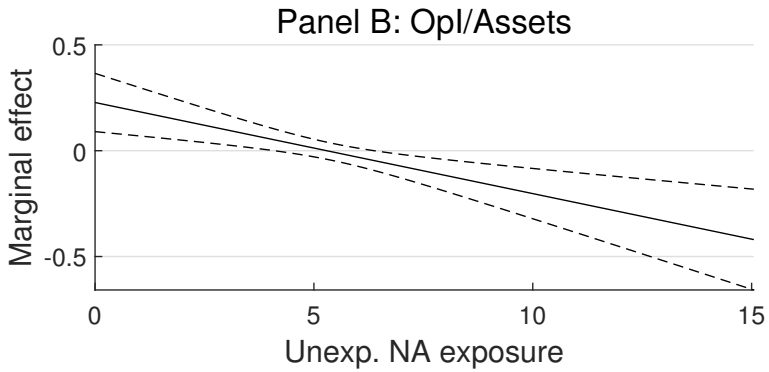
Accounting performance

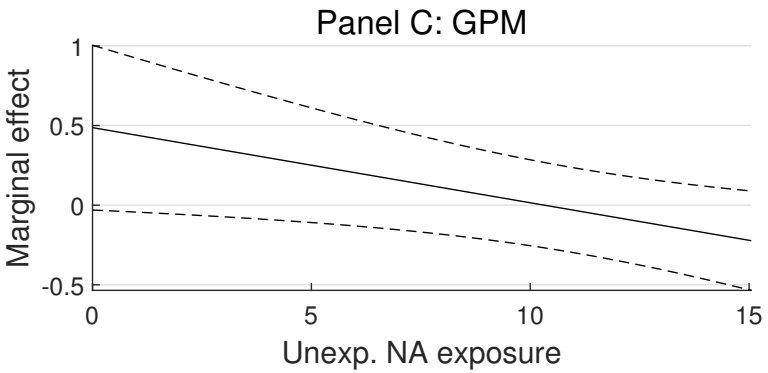
- Do short-term market reactions to nonattainment designations accurately reflect the long-term effects?
- Firm-level stacked DiD.

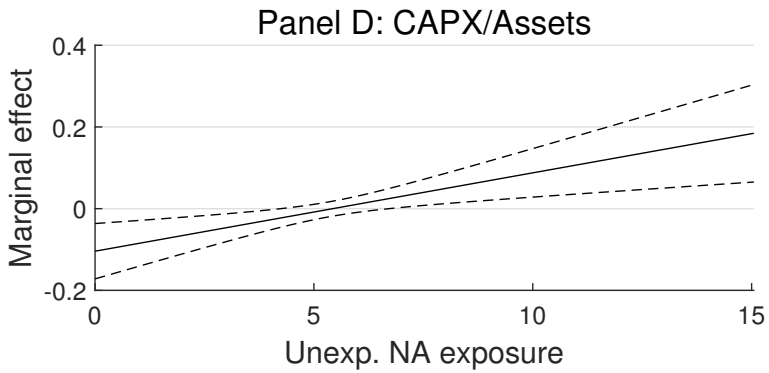
Dep. variable:	*Rev/Assets*	*OpI/Assets*	*GPM*	*CAPX/Assets*	*COGS/Assets*
	(1)	(2)	(3)	(4)	(5)
Unexp. NA exposure × *Post*	0.510*	0.228***	0.487*	-0.104***	-1.224**
	(1.80)	(3.24)	(1.84)	(-3.01)	(-2.32)
Unexp. NA exposure^2 × *Post*	-0.068***	-0.022***	-0.024**	0.010***	0.123***
	(-2.68)	(-3.47)	(-2.30)	(3.09)	(2.66)
Antic. NA exposure × *Post*	-0.271	0.031	-1.307	-0.033	-0.030
	(-1.04)	(0.47)	(-1.11)	(-0.79)	(-0.12)
Antic. NA exposure^2 × *Post*	0.034	-0.001	0.094	0.002	-0.024
	(1.43)	(-0.09)	(1.12)	(0.53)	(-1.05)
Controls	Yes	Yes	Yes	Yes	Yes
F-statistic	7.32	6.04	2.67	4.78	4.05
p-value	0.000	0.002	0.069	0.008	0.017
Year × Cohort F.E.	Yes	Yes	Yes	Yes	Yes
Firm × Cohort F.E.	Yes	Yes	Yes	Yes	Yes
Observations	15,056	14,683	13,900	14,852	14,886
Adj R^2	0.92	0.63	0.13	0.62	0.90

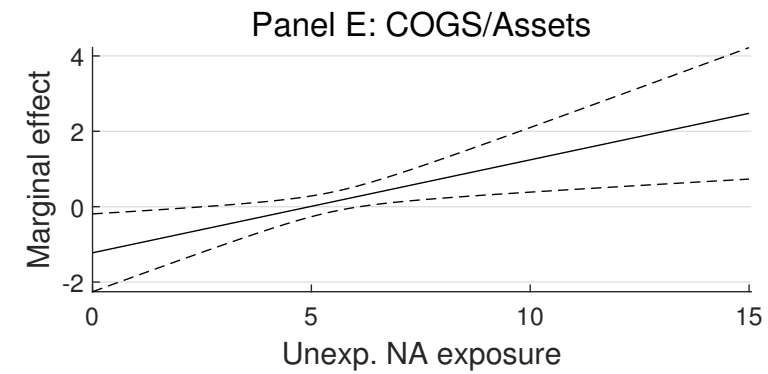
Marginal effects











Conclusion

- Stock market internalizes the perceived benefits and costs of local environmental regulation.
- Currently, there are no federal regulations aimed at mitigating global pollutants that contribute to climate change.
- Local environmental regulations contain value-relevant information that have stock-price implications for polluting firms.
- Any cost-benefit analysis of new climate policy must take into account the impact on financial markets.

Thank you!

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