Environmental regulatory risks, firm pollution, and mutual funds' portfolio choices

Simon Xu[†]

[†]UC Berkeley, Haas School of Business

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What is this paper about?

- Concerns about environmental risk (Bolton & Kacperczyk, 2021; Ceccarelli et al., 2021; Ilhan et al., 2021; Dimson et al., 2015).

- Environmental *regulatory* risks:
  - ▶ Paramount importance over the next five years (Stroebel & Wurgler, 2021).
  - ▶ Already starting to materialize (Krueger et al., 2020).

- Previous research:
  - ▶ Pricing of municipal bonds (Jha et al., 2020).
  - ▶ Corporate bonds (Seltzer et al., 2021).
  - ▶ Bank loans (Delis et al., 2021; Kleimeier & Viehs, 2018).
  - ▶ Shareholder wealth (Choi et al., 2022).

- Relatively less work that explores how the interplay between environmental regulations and firm pollution impact on investors' rational investment decisions.

- We fill this gap by focusing on an important group of investors whose trading we can observe, mutual funds, and examine how they rebalance their portfolio holdings of polluting firms in response to environmental regulations.
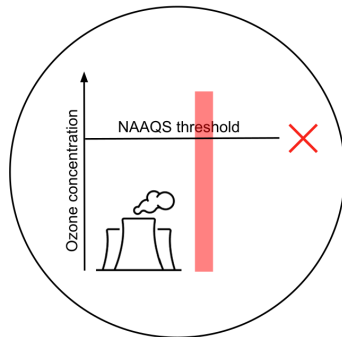
Nonattainment designations

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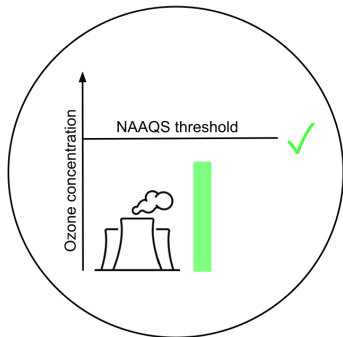
Regulatory costs

Implications for firms

- Operate polluting plants located in nonattainment counties.
  - ▶ Stringent regulations and mandatory pollution abatement requirements.
  - ▶ Additional regulatory costs.
- Nonattainment regulations are **binding** (Chay & Greenstone, 2003; Henderson, 1996; Greenstone, 2002).
  - ▶ ↑ compliance costs, compared to those in attainment counties.

- Use county-level ozone nonattainment designations → exogenous source of variation in local regulatory stringency → negative shock to the *cash flows* of polluting firms exposed to these regulations.

Hedging against regulatory risk ("Rational hypothesis")

- Mutual funds adjust their portfolio holdings to hedge against nonattainment regulatory risk.
  - ▶ Green tastes + ESG demand (Pástor et al., 2021; Pedersen et al., 2021) → consumer preference for green + pressure on institutional investors to divest from brown → Green non-polluting stocks as hedge?
  - ▶ Regulatory stringency due to ↑ brown firms' output (Baker et al., 2022) → positive unexpected returns → Brown stocks better hedges?
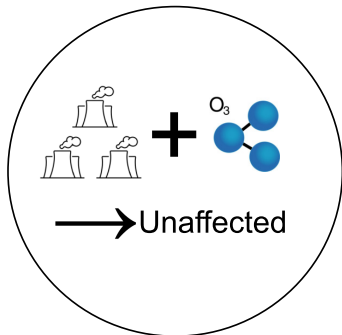
Mechanism: Negative shock to cash flows

1. Ozone-polluting firms with a greater exposure to nonattainment designations experience greater regulatory costs (Ryan, 2012).

2. Negatively impact on firm fundamentals (e.g., riskier operating cash flows).

3. Funds optimally adjust their portfolio holdings depending on how the cash flows of the stock covary with the regulatory shock.
   - ▶ Stocks that perform better when there is a nonattainment regulatory shock serve as a regulatory-risk hedge → overweighted.
   - ▶ Vice versa, stocks that perform poorly during a nonattainment regulatory shock → underweighted.
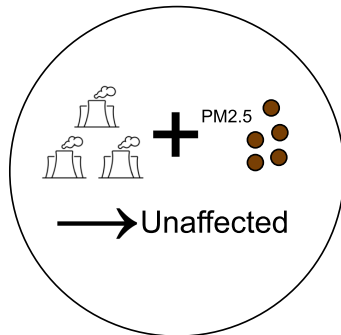
Which firms are underweighted?

Not all polluting firms are regulated uniformly

Example 1: Attainment county   **Example 2: Nonattainment county**

"Extensive margin"   "Intensive margin"

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Which firms are most negatively affected?

- Our unique setting that exploits local variation in regulatory stringency allows us to precisely identify which stocks experience additional regulatory costs given a nonattainment designation.
- Multi-plant firms:
  - ▶ Regulated the most intensely and generally targeted first by regulators (Becker & Henderson, 2000).
  - ▶ Higher production costs (Becker & Henderson, 2001).
- Heavy ozone polluters:
  - ▶ Higher air pollution abatement expenditures and operating costs (Becker, 2005).
- Multi-plant + Heavy ozone polluter → negative shock to cash flows when exposed to nonattainment regulations → underweighted.

Sample construction

- Mutual fund data: CRSP Survivor-Bias-Free U.S. Mutual Fund Database.
  - ▶ Portfolio holdings: Thomson Reuters mutual fund holdings.
  - ▶ 3,271 unique funds from 1991 to 2019.
- Firm plant-level pollution data: EPA's TRI database.
  - ▶ Manually map TRI chemicals into ozone and non-ozone pollutants.
  - ▶ 1,625 unique public parent firms from 1991 to 2019.
- Nonattainment designations from the Federal Register.
  - ▶ Manually collect the effective dates of every event.
  - ▶ 1,286 nonattainment designation county-event-quarters involving 896 firms.
- Final sample: 3,644,290 fund-stock-quarter observations between 1991 to 2019.

Nonattainment designations as a research design

- Policy changes in the NAAQS threshold and change in the number of nonattainment counties.
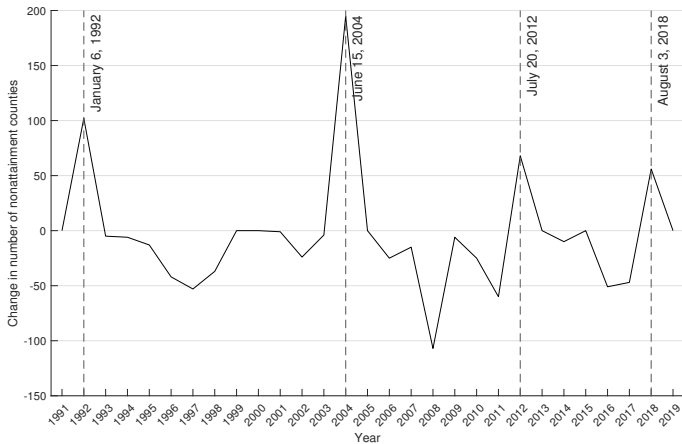
Empirical specification

- Diff-in-diff: Focus on a five-quarter window around nonattainment designation quarter.

$$\Delta w_{m,s} = \beta_0 + \beta_1 NA\ ratio_{s,t} + \beta_2 Ozone\ ratio_{s,t-1} + \beta_3 NA\ ratio_{s,t} \times Ozone\ ratio_{s,t-1}$$
$$+ X_{s,t-1} + X_{m,t-1} + \mu_m + \tau_s + \rho_t + \varepsilon_{m,s,t}$$

$$(1)$$

for fund m, stock s, and quarter t.

- $\Delta w_{m,s}$: change in the average weights (in percentage points) of a given stock in a given mutual fund's portfolio.
- *Ozone ratio*: ozone air emissions (in pounds) for a given plant as a proportion of the plant's overall air emissions (in pounds), averaged across all plants owned by a given firm.
- *NA ratio*: number of polluting plants located in nonattainment counties for a given firm divided by the total number of polluting plants owned by the firm.
- Prediction: negative β_3.

Response to nonattainment designations

- Median effect: $\uparrow$ std. dev. in *NA ratio* and *Ozone ratio* $\rightarrow$ $\downarrow$ 1.17% in the dollar value.
- Extensive margin effect: Firm with all ozone plants + fully exposed to nonattainment vs. Firm with only non-ozone plants without any exposure to nonattainment $\rightarrow$ $\downarrow$ 9.8% in the dollar value.

Dep. variable: Δw	(1)	(2)	(3)	(4)	(5)	(6)	(7)
NA ratio$_t$	0.022***	0.020***	0.020***	0.017***	0.020***	0.016***	0.018***
	(4.68)	(4.12)	(4.10)	(3.24)	(3.31)	(3.06)	(3.07)
Ozone ratio$_{t-1}$	0.016***	0.020***	0.016***	0.022***	0.014*	0.020***	0.012*
	(3.04)	(3.34)	(2.96)	(3.40)	(1.93)	(3.07)	(1.69)
NA ratio$_t$ $\times$ Ozone ratio$_{t-1}$	-0.018**	-0.027***	-0.018**	-0.026***	-0.027***	-0.024***	-0.025**
	(-2.33)	(-3.10)	(-2.20)	(-2.79)	(-2.62)	(-2.62)	(-2.44)
Stock controls	No	Yes	No	Yes	Yes	Yes	Yes
Fund controls	No	No	Yes	Yes	Yes	No	No
Fund $\times$ Stock F.E.	No	No	No	No	Yes	No	Yes
Fund $\times$ Year-Quarter F.E.	No	No	No	No	No	Yes	Yes
Fund F.E.	Yes	Yes	Yes	Yes	No	No	No
Stock F.E.	Yes	Yes	Yes	Yes	No	Yes	No
Year-Quarter F.E.	Yes	Yes	Yes	Yes	Yes	No	No
Observations	426,683	382,744	385,441	339,980	205,867	339,979	205,865
Adj R^2	0.04	0.04	0.04	0.04	0.01	0.06	0.05

Temporal dynamics around nonattainment designations

- Absence of pre-trends: no differential response in portfolio weights before nonattainment designations.
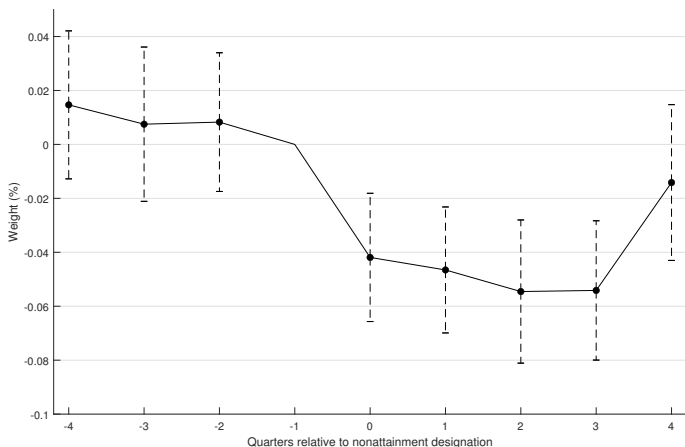
Additional results

- Controlling for event anticipation (Borochin et al., 2022).
    - Driven by *unexpected* nonattainment designations.

- Underweighting is stronger for:
    - Firms that do not own an ozone operating permit.
    - Firms that operate plants that are located close to nonattainment monitors.
    - Firms that operate young plants.
    - Small funds.
    - Concentrated funds.

- Alternative dependent variables:
    - Complete share divestments.
    - Change in the number of shares.
    - Average dollar value of shares traded.

- Heterogeneity of chemicals: Toxicity-weighted ozone air emissions.

- Mitigate reporting errors in TRI data: Core chemicals only.

- Falsification test: Offsite ozone air emissions.

- Relative importance of different plants: Facility-level employee and sales weighted *NA ratio*.

- Self-selecting into nonattainment: Heckman selection model.

- Funds' sustainability footprint.

- Demand for ESG investment fund flows.

Response to bump-ups

- Bump-ups increase the intensity of regulation in already nonattainment counties.
- Median effect: $\uparrow$ std. dev. in *Bump ratio* and *Ozone ratio* $\rightarrow \downarrow$ 1.58% in the dollar value.

Dep. variable: Δw	(1)	(2)	(3)	(4)
Bump ratio$_t$	0.026***	0.022***	0.022***	0.017**
	(3.81)	(2.97)	(3.29)	(2.27)
Ozone ratio$_{t-1}$	0.047***	0.045***	0.051***	0.048***
	(4.41)	(3.94)	(4.69)	(4.11)
Bump ratio$_t$ × *Ozone ratio*$_{t-1}$	-0.106***	-0.097***	-0.104***	-0.091***
	(-6.44)	(-5.58)	(-6.33)	(-5.16)
Stock controls	Yes	Yes	Yes	Yes
Fund controls	Yes	Yes	No	No
Fund × Stock F.E.	No	Yes	No	Yes
Fund × Year-Quarter F.E.	No	No	Yes	Yes
Fund F.E.	Yes	No	No	No
Stock F.E.	Yes	No	Yes	No
Year-Quarter F.E.	Yes	Yes	No	No
Observations	298,456	230,478	296,875	227,987
Adj R^2	0.03	0.01	0.09	0.05

Temporal dynamics around bump-ups

- Absence of pre-trends.
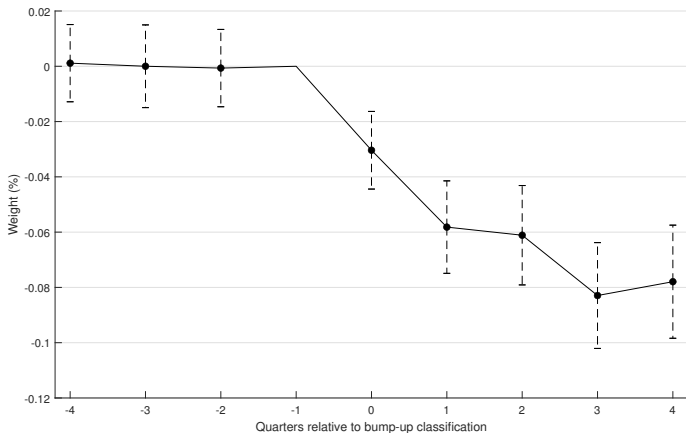
Response to attainment redesignations

- Attainment redesignations represent an ease in regulation.
- Median effect: $\uparrow$ std. dev. in *Redesig ratio* and *Ozone ratio* $\rightarrow$ $\uparrow$ 1.76% in the dollar value.

Dep. variable: Δw	(1)	(2)	(3)	(4)
Redesig ratio$_t$	-0.065***	-0.058**	-0.092***	-0.053**
	(-2.47)	(-1.98)	(-3.32)	(-2.37)
Ozone ratio$_{t-1}$	-0.081***	-0.083***	-0.133***	-0.105***
	(-3.66)	(-3.28)	(-4.52)	(-3.35)
Redesig ratio$_t$ × Ozone ratio$_{t-1}$	0.109***	0.163***	0.143***	0.106**
	(2.58)	(3.74)	(2.59)	(2.39)
Stock controls	Yes	Yes	Yes	Yes
Fund controls	Yes	Yes	No	No
Fund × Stock F.E.	No	Yes	No	Yes
Fund × Year-Quarter F.E.	No	No	Yes	Yes
Fund F.E.	Yes	No	No	No
Stock F.E.	Yes	No	Yes	No
Year-Quarter F.E.	Yes	Yes	No	No
Observations	373,808	305,932	364,474	293,765
Adj R^2	0.03	0.03	0.11	0.15

Temporal dynamics around attainment redesignations

- Absence of pre-trends.

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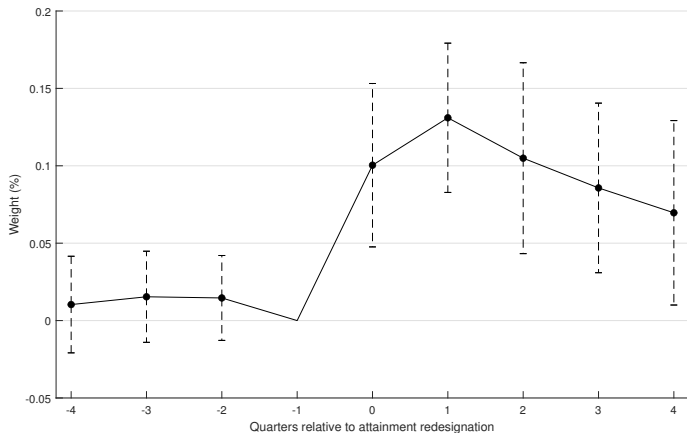
Alternative explanation: Salience hypothesis

> **Salience hypothesis (Alok et al., 2020; Huynh et al., 2021; Foroughi et al., 2021; Alekseev et al., 2022)**
>
> - Fund managers' *local* exposure to environmental risks → amplifies salience → overestimate impact on affected firms → underweight affected stocks.
> - Our setting: local exposure to ozone-polluting firms → overestimate costs of nonattainment → underweight due to overreaction.

- Different performance implications in the post-nonattainment period:
  - ▶ Return reversals → Salience hypothesis.
  - ▶ ↓ Operating performance, ↓ Abnormal stock returns, ↑ Fund portfolio performance → Rational hypothesis.

Operating performance

- Heavy ozone-polluters $+$ nonattainment exposure $\rightarrow$ negative shock to cash flows $\rightarrow$ adverse impact on profitability post-nonattainment.

Dep. variable:	ROA_t	ROS_t	Sales growth$_t$
	(1)	(2)	(3)
$NA\ ratio_t \times Post_t$	0.008***	0.023**	0.076*
	(2.60)	(2.22)	(1.90)
$Ozone\ ratio_{t-1} \times Post_t$	0.002	0.011*	0.039**
	(1.23)	(1.66)	(2.26)
$NA\ ratio_t \times Ozone\ ratio_{t-1} \times Post_t$	-0.015***	-0.037**	-0.112**
	(-2.64)	(-2.47)	(-2.00)
Stock controls	Yes	Yes	Yes
Stock F.E.	Yes	Yes	Yes
Industry F.E.	Yes	Yes	Yes
Year-Quarter F.E.	Yes	Yes	Yes
Observations	9,066	8,983	9,168
Adj R^2	0.61	0.55	0.06

DGTW-adjusted CARs

- Double sort based on median *NA ratio* and *Ozone ratio* values.
  - ▶ Above median *Ozone ratio* → Top emitters.
  - ▶ Above median *NA ratio* → Highly regulated.
- Focus on top emitters and split into high vs low regulated.

Panel A: Highly regulated firms				
		Horizon		
Tercile	Year−1	Year+1	Year+2	Year+3
1 (Underweighted)	0.022	-0.023	-0.004	0.015
	(1.25)	(-1.15)	(-0.13)	(0.40)
2	-0.023	0.016	0.087***	0.140***
	(-0.96)	(0.55)	(2.66)	(4.03)
3 (Overweighted)	0.010	0.059***	0.121***	0.151***
	(0.61)	(2.99)	(4.49)	(4.78)
1 − 3	0.012	-0.082***	-0.125***	-0.136***
	(0.48)	(-2.93)	(-2.98)	(-2.74)

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Panel B: Least regulated firms

	Horizon			
Tercile	Year-1	Year$+1$	Year$+2$	Year$+3$
1 (Underweighted)	-0.003	0.019	0.043	0.061
	(-0.15)	(0.86)	(1.02)	(1.38)
2	-0.040	0.015	0.117**	0.116**
	(-1.39)	(0.45)	(2.11)	(2.04)
3 (Overweighted)	0.037*	0.023	0.043	0.077*
	(1.66)	(1.15)	(1.55)	(1.88)
$1-3$	-0.040	-0.004	0.000	-0.016
	(-1.29)	(-0.15)	(0.00)	(-0.26)

Panel C: Difference between highly and least regulated firms

	Horizon			
Tercile	Year-1	Year$+1$	Year$+2$	Year$+3$
1 (Underweighted)	0.025	-0.042	-0.048	-0.046
	(0.90)	(-1.42)	(-0.90)	(-0.45)
2	0.017	0.001	-0.030	0.024
	(0.44)	(0.02)	(-0.47)	(0.14)
3 (Overweighted)	-0.027	0.036	0.077**	0.074
	(-0.97)	(1.26)	(1.98)	(0.84)
$1-3$	0.052	-0.078**	-0.125**	-0.120*
	(1.32)	(-2.12)	(-2.00)	(-1.69)

Funds' portfolio performance

- *Low Δw*: Lowest tercile when sorting funds based on average change in weights for top ozone emitting and highly regulated firms.
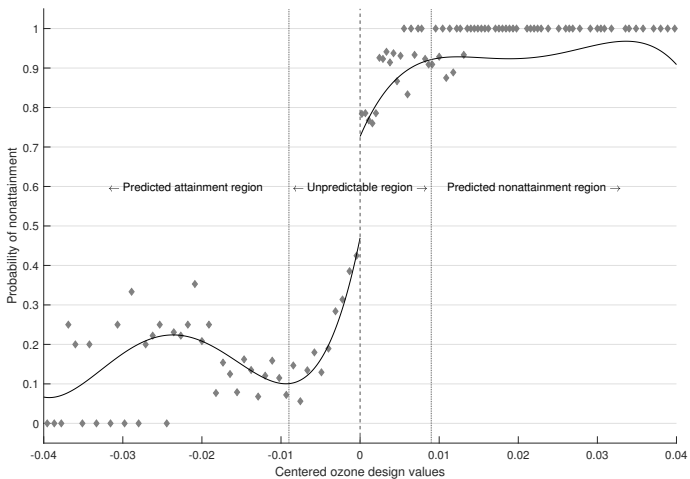
Dep. variable:	Mean portfolio return	Total portfolio risk	Sharpe ratio	Alpha FF3
	(1)	(2)	(3)	(4)
Low $\Delta w \times Post[0, 2]$	0.000	-0.002***	0.006***	0.018
	(0.43)	(-3.80)	(4.71)	(1.33)
Low $\Delta w \times Post[3, 4]$	0.003***	-0.000	0.004***	0.073***
	(5.19)	(-0.89)	(3.16)	(4.00)
Low $\Delta w \times Post[5, 6]$	0.003***	-0.000	0.003***	0.073***
	(3.37)	(-0.22)	(3.16)	(3.47)
Low $\Delta w \times Post[7, 8]$	0.004***	0.001	0.002*	0.068***
	(3.97)	(1.39)	(1.69)	(3.61)
Low $\Delta w \times Pre[-4, -3]$	-0.000	0.000	-0.000	0.009
	(-0.21)	(0.86)	(-0.38)	(0.83)
Low $\Delta w \times Pre[-6, -5]$	0.000	-0.000	0.001	0.025
	(0.10)	(-0.22)	(1.09)	(1.18)
Low Δw	-0.002*	0.001	-0.003**	-0.058***
	(-1.78)	(0.88)	(-2.42)	(-2.96)
Value-weighted stock controls	Yes	Yes	Yes	Yes
Fund controls	Yes	Yes	Yes	Yes
Fund F.E.	Yes	Yes	Yes	Yes
Year-Quarter F.E.	Yes	Yes	Yes	Yes
Observations	29,535	29,535	29,535	29,535
Adj R^2	0.65	0.71	0.48	0.51

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- Examine mutual funds' portfolio choices in response to environmental regulatory risks.
    - ▶ Underweight (overweight) those polluting stocks whose cash flows covary negatively (positively) with the regulatory shock.
    - ▶ Underweight (overweight) heavy ozone-polluting firms exposed to nonattainment designations and bump-ups (attainment redesignations).
- Environmental regulations have important implications for the allocation of capital of polluting firms in financial markets.
    - ▶ Shift capital away from biggest polluters $\rightarrow$ $\uparrow$ value of funds' portfolio.
    - ▶ Detrimental to overall welfare? These firms need funding to transition to greener economy.
- Exciting avenues for future research on the welfare implications.

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Thank you!

Event anticipation

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