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

Simon Xu†

Abstract

This paper examines how mutual funds' portfolio holdings respond to environmental regulations. Using county-level ozone nonattainment designations induced by discrete policy changes in the National Ambient Air Quality Standards as a source of exogenous variation in environmental regulation, we find that funds underweight (overweight) those polluting stocks whose cash flows covary negatively (positively) with the regulatory shock. Our results are consistent with hedging adjustments in response to expected changes in firm fundamentals due to negative cash flow shocks stemming from the costs of nonattainment regulation. Further analysis in the post-nonattainment period shows that heavy ozone-polluting firms exposed to nonattainment designations experience worse profitability. The most underweighted of such firms also exhibit worse abnormal stock return performance and are subject to more regulatory compliance costs. Such underweighting translates into better fund portfolio performance.

JEL Classification: G11; G18; G23; Q50; Q53
Keywords: environmental regulation, pollution, mutual funds, portfolio choices

*We greatly appreciate the comments of Pat Akey, Stefano Battiston, Alex Edmans, Brahim Gaies, Stefano Giglio, Amit Goyal, Lixiong Guo, Marcin Kacperczyk, Chang-Mo Kang, Stephen Karolyi, Adrian Lam, Ross Levine, Yingxiang Li, Tse-Chun Lin, Andrew Lo, Ulrike Malmendier, Timothy McQuade, Ji Yeol Jimmy Oh, Christine Parlour, Stefano Ramelli, Joseph Shapiro, David Sraer, Jan Starmans, Dragon Yongjun Tang, Luca Taschini, Annette Vissing-Jørgensen, Johan Walden, Reed Walker, Ying Xia, Chelsea Yao, Hong Zhang, Shuang Zhang, Qifei Zhu, and seminar participants at UC Berkeley Haas School of Business, UC Berkeley Department of Economics, LBS Trans-Atlantic Doctoral Conference 2022, International Risk Management Conference 2022, International Research Meeting in Business and Management 2022, China International Conference in Finance 2022, European Finance Association Annual Meeting 2022, Global Research Alliance for Sustainable Finance and Investment Annual Conference 2022, Asia Conference on Business and Economic Studies 2022, Frontiers of Factor Investing Conference 2022, CREDIT International Conference in Venice on Long Run Risks 2022, Melbourne Asset Pricing Meeting 2022, EBA Policy Research Workshop 2022, Financial Management Association Annual Meeting 2022, OFR PhD Symposium 2022, and DePaul University Conference on CSR, the Economy and Financial Markets 2022. We also thank the EPA for helpful discussions on data. All remaining errors are our own.

†Haas School of Business, University of California at Berkeley, Berkeley, CA 94720, United States; email simon_xu@haas.berkeley.edu.

1. Introduction

Recently, institutional investors have become increasingly concerned about the environmental risks embedded in their portfolio choices (e.g., Bolton & Kacperczyk, 2021; Cao, Titman, Zhan, & Zhang, 2021; Ilhan, Krueger, Sautner, & Starks, 2021; Starks, Venkat, & Zhu, 2020). In particular, environmental *regulatory* risks have been identified by both academics and practitioners to be of paramount importance over the next five years (Stroebel & Wurgler, 2021), and are widely believed to have already started to materialize (Krueger, Sautner, & Starks, 2020). Although research has shown that environmental regulatory risks affect the pricing of municipal bonds (Jha, Karolyi, & Muller, 2020), corporate bonds (Seltzer, Starks, & Zhu, 2021), and bank loans (Delis, de Greiff, Iosifidi, & Ongena, 2021; Kleimeier & Viehs, 2018), there has been relatively less work that explores how the interplay between environmental regulations and firm pollution impacts 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.

The institutional setting employed in this paper centers on a key regulatory component of the Clean Air Act (CAA), whereby counties are designated as "attainment" or "nonattainment" with respect to the National Ambient Air Quality Standards (NAAQS) for ozone. Through the NAAQS, the federal United States Environmental Protection Agency (EPA) sets maximum allowable ambient concentrations of ozone pollution. Counties with ozone pollution levels above the NAAQS threshold are deemed to be noncompliant (nonattainment), while those with pollution levels below the threshold are in compliance (attainment). Firms that operate polluting plants located in nonattainment counties face stringent regulations and mandatory pollution abatement requirements, which substantially increases their compliance costs, compared to those in attainment counties. Thus, our empirical strategy exploits county-level ozone nonattainment designations as an exogenous source of variation in local regulatory stringency that represents a negative shock to the cash flows of polluting firms exposed to these regulations.

How mutual funds adjust their holdings of polluting firms in response to nonattainment designations will depend on which stocks hedge against nonattainment regulatory risk (Pástor, Stambaugh, & Taylor, 2021). On the one hand, green non-polluting stocks may serve as appropriate hedges because more stringent regulations to polluting firms could heighten consumers' preferences for goods and services from greener firms (Pástor et al., 2021). Similarly, these stringent regulations may also strengthen investors' preferences for green holdings if there is public pressure on institutional investors to divest from brown firms (Pedersen, Fitzgibbons, & Pomorski, 2021). On the other hand, one can make the argument that better hedges are brown polluting stocks. Baker, Hollifield, and Osambela (2022) argue that an increase in the regulatory stringency of brown firms stems from positive shocks to their output, which translates to positive unexpected returns on those firms' stocks, thereby making brown stocks better hedges. As summarized by Pástor et al. (2021), whether brown stocks or green stocks serve as hedges against environmental regulatory risks, and hence how funds respond to such risks, is ultimately an empirical question.

While investors' portfolio adjustments of polluting and non-polluting stocks in both Pástor et al.'s (2021) and Pedersen et al.'s (2021) framework is driven by environmental, social, and governance (ESG) demand, we argue that, in our setting, the negative shock to the cash flows of polluting firms exposed to nonattainment designations is what drives mutual funds' portfolio responses. Also unique to our institutional setting is that not all firms are regulated uniformly under nonattainment designations. For example, a firm that operates many ozone-polluting plants, but are all located in attainment counties, is unaffected by the regulation. Similarly, a firm that operates many polluting plants in nonattainment counties, but none of the plants emit ozone, is also unaffected. Therefore, the impact of nonattainment designations on a firm's cash flows depends on its reliance on ozone emissions for production and its exposure to nonattainment regulatory shocks.

The underlying economic mechanism is that ozone-polluting firms with a greater exposure to nonattainment designations experience greater regulatory costs (Ryan, 2012), which negatively impact on their firm fundamentals through riskier operating cash flows (Bolton & Kacperczyk, 2021; Hsu, Li, & Tsou, 2022; Jouvenot & Krueger, 2021). Funds then adjust their portfolio holdings to hedge against nonattainment regulatory risk 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 and are consequently overweighted. Vice versa, stocks that perform poorly during a nonattainment regulatory shock are underweighted. We call this the "rational hypothesis".

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. Specifically, prior studies show that *multi-plant* firms in nonattainment areas face higher production costs relative to their less-regulated counterparts in attainment areas because such firms are regulated the most intensely and generally targeted first by regulators (Becker & Henderson, 2000, 2001). Additionally, Becker (2005) shows that *heavy ozone emitters* in nonattainment counties have higher air pollution abatement expenditures and operating costs than otherwise similar heavy emitters in attainment counties. Taken together, multi-plant firms that are also heavy ozone emitters in nonattainment counties face the majority of the regulatory costs associated with nonattainment designations. Thus, under the rational hypothesis, we predict that funds hedge against nonattainment regulatory risk by underweighting heavy ozone-polluting firms that operate many plants in nonattainment counties.

Our empirical design relies on nonattainment designations induced by discrete policy changes in the NAAQS threshold from 1991 to 2019. The policy changes that we employ are based on EPA's periodic revisions to reflect new scientific research on the health effects of ozone air pollution. Given an exogenous revision in the NAAQS threshold that defines noncompliance, many counties suddenly found themselves in nonattainment relative to the year prior even if their pollution levels remained constant. To empirically test the rational hypothesis, we examine changes in portfolio weights of ozone-polluting firms exposed to nonattainment designations in a difference-in-differences specification. Since a firm can operate many plants across multiple counties, we capture a firm's exposure to nonattainment designations using the proportion of its plants located in nonattainment counties. Additionally, since nonattainment regulations only apply to ozone emitting plants under ozone NAAQS, we use the Toxics Release Inventory (TRI) database to classify facility emissions into ozone and non-ozone pollutants.

The main finding is that funds underweight heavy ozone-polluting stocks that are also heavily regulated under nonattainment designations. Economically, a firm that operates all ozone plants and becomes fully exposed to nonattainment designations experiences a reduction of 9.8% in the dollar value of holdings in a median fund's portfolio compared to one that operates only non-ozone plants without any exposure to nonattainment designations. We also find that funds reallocate holdings toward firms that are exposed to nonattainment designations but operate only non-ozone plants and firms that operate ozone plants but are located in attainment counties, which is consistent with the predictions of the rational hypothesis since both types of firms are unaffected by nonattainment designations. Our results are robust to the inclusion of various firm and fund-level control variables (e.g., firm leverage, value, size, profitability, and returns; fund size, expense ratio, turnover, returns, and flows), stringent sets of fixed effects (fund, stock, year-quarter, fund $\times$ stock, and fund $\times$ year-quarter), and alternative measures of the outcome variable (complete divestment, number of shares, and value of shares traded). Importantly, we confirm that there are no differential trends in the portfolio weights of heavy ozone-polluting stocks exposed to nonattainment designations compared to less-affected stocks in the pre-nonattainment period.

Since the monitored pollution levels used to determine nonattainment status are observable, attentive fund managers may be able to anticipate a county's nonattainment status, which may bias downwards the estimated portfolio responses (Borochin, Celik, Tian, & Whited, 2022). Our analysis controls for event anticipation by using a regression discontinuity design (RDD) to decompose changes in portfolio weights into an unexpected and anticipated component based on whether managers' predictions of nonattainment status are in line with or differ to realized nonattainment designations. Our findings show that funds only underweight those heavy ozone-polluting stocks operating plants located in counties experiencing unexpected nonattainment designations. This result is consistent with the interpretation that funds only hedge against unexpected regulatory shocks, since any portfolio changes spurred by the anticipated component should have been incorporated before the nonattainment designation event.

We further explore possible heterogeneity in portfolio responses to nonattainment designations by focusing on certain firm characteristics that impose additional costs during nonattainment designations, and hence, lead to a more negative shock to cash flows. We also examine various fund characteristics that are associated with a greater likelihood of fund managers hedging against nonattainment regulatory risk. Specifically, we argue that the regulatory costs of nonattainment are greater for firms that do not own an ozone operating permit (Walker, 2013), operate plants that are located close to nonattainment monitors (Auffhammer, Bento, & Lowe, 2009; Bento, Freedman, & Lang, 2015; Gibson, 2019), and operate young plants (Becker & Henderson, 2000, 2001). In terms of funds characteristics, we posit that smaller funds (Pool, Stoffman, & Yonker, 2012) and more concentrated funds (Kacperczyk, Sialm, & Zheng, 2005) have greater incentives to hedge against nonattainment regulatory shocks. In line with the predictions of the rational hypothesis, we find that the aforementioned firm and fund characteristics are associated with more underweighting of heavy ozone-polluting firms exposed to nonattainment designations.

In the next set of analyses, we study portfolio responses to two related types of regulatory shocks: bump-up classifications and redesignations to attainment. Bump-ups occur when a nonattainment county fails to demonstrate attainment by a specified date and is "bumped-up" from a lower classification of nonattainment to a more severe one. Thus, bump-ups represent an increase in the intensity of regulation. Since heavy ozone-polluting firms exposed to bump-ups experience an increase in regulatory costs, which further negatively impacts on their cash flows, the rational hypothesis predicts a similar portfolio response to that of nonattainment designations whereby such stocks are underweighted. Using a similar difference-in-differences setting, we find that funds underweight heavy ozone-polluting firms exposed to bump-ups and confirm the absence of pre-trends. Decomposing portfolio responses to bump-ups into an unexpected and anticipated component, we find that funds only underweight heavy ozone-polluting stocks operating in unexpected bump-up counties, consistent with funds hedging against unexpected cash flow shocks.

Redesignations to attainment, on the other hand, occur when a county has attained the NAAQS and represent an easing of regulation. Thus, attainment redesignations favor those heavy ozone-polluting firms operating plants in existing nonattainment counties due to a reduction in compliance costs, which leads to a positive shock to their cash flows (Ramelli, Wagner, Zeckhauser, & Ziegler, 2021). Consistent with the predictions of the rational hypothesis, we find that funds adjust their portfolio holdings in the opposite direction when compared to nonattainment designations by overweighting heavy ozone-polluting stocks exposed to attainment redesignations. We confirm that there are no pre-trends in portfolio weights driving our results and that funds only adjust their holdings in response to the unexpected component of attainment redesignations. Furthermore, the same firm and fund characteristics that are associated with more underweighting during nonattainment designations now lead to more overweighting.

Although the underweighting of the most negatively impacted firms is consistent with fund managers adjusting their portfolio holdings to hedge against nonattainment regulatory risk, we also recognize that such underweighting could be a result of salience bias (Alekseev, Giglio, Maingi, Selgrad, & Stroebel, 2022; Alok, Kumar, & Wermers, 2020; Foroughi, Marcus, & Nguyen, 2021; Huynh, Li, & Xia, 2021). In our setting, the so-called "salience hypothesis" implies that fund managers with a *local* exposure to ozone-polluting firms may overestimate the costs of nonattainment regulations on these firms, and consequently, underweight such stocks in their portfolio holdings due to an overreaction.

To distinguish between these two interpretations, we examine the different implications that these hypotheses have on the future performance of the underweighted stocks and associated fund portfolio performance. Since the rational hypothesis is based on expected changes in firm fundamentals due to the costs of nonattainment regulation, we would expect a drop in the performance of heavy ozone-polluting firms in the post-nonattainment period. Indeed, we find that heavy ozone-polluting firms that are exposed to nonattainment designations experience a decrease in profitability in the post-nonattainment period when compared to less-affected firms. We also evaluate the abnormal stock returns of the most underweighted heavy ozone-polluting stocks that are highly regulated in the post-nonattainment period. If the underweighting is consistent with the rational hypothesis, we would expect the most underweighted stocks to persistently exhibit worse abnormal return performance in the post-nonattainment period. On the other hand, any signs of return reversals would be consistent with the salience hypothesis. Examining the cumulative abnormal returns (CARs) of top ozone-polluting firms that are heavily regulated, we find that the most underweighted of such stocks subsequently underperform those stocks that are most overweighted, with no signs of return reversals.

In terms of portfolio performance, we find that the funds that engage in the most underweighting experience superior portfolio performance in the post-nonattainment period. Our results are consistent with funds making optimal hedging adjustments in response to regulatory risks and not due to managers' overreaction to the costs of nonattainment designations. In our final set of analysis, we examine whether the underweighted top ozone-polluting firms that funds expect to be most negatively impacted by nonattainment designations actually are subject to more regulatory compliance costs in the post-nonattainment period. Using a facility's observable pollution abatement efforts and regulatory enforcement as proxies for potential compliance costs, we find that the regulatory compliance costs of such firms increase with their exposure to nonattainment designations in the post-nonattainment period.

Our paper contributes to the burgeoning literature that examines mutual funds' portfolio choice in response to environmental risks. Recent studies provide empirical evidence that institutional investors take into account climate risk considerations in their investment portfolio decisions (Gibson, Krueger, & Mitali, 2021; Hoepner, Oikonomou, Sautner, Starks, & Zhou, 2022; Jagannathan, Ravikumar, & Sammon, 2022). Some papers study portfolio changes in response to climate risks through ESG demand and preferences (Baker et al., 2022; Pástor et al., 2021; Pedersen et al., 2021), while others focus on local exposure to environmental risks to provide behavioral explanations based on salience bias for the portfolio choice decisions of mutual funds (Alok et al., 2020; Foroughi et al., 2021; Huynh et al., 2021) and individual investors (Bharath & Cho, 2022; Choi, Gao, & Jiang, 2020; Li, Massa, Zhang, & Zhang, 2021).

We add to this literature by examining the relatively underexplored topic of environmental *regulatory* risks and show that funds hedge against such risks by rebalancing portfolio holdings based on how the cash flows of polluting firms covary with the regulatory shock.

Our study also contributes to the literature that examines the environmental regulatory determinants of institutional investors' stock holdings. Prior work on non-regulatory environmental determinants of institutional investors' holdings include competition for climate-conscious investment flows (Ceccarelli, Ramelli, & Wagner, 2021), firms' ESG profiles (Borgers, Derwall, Koedijk, & ter Horst, 2015; Chava, 2014; Nofsinger, Sulaeman, & Varma, 2019; Starks et al., 2020), and news about a firm's corporate environmental policies (Gantchev, Giannetti, & Li, 2021). Some studies have examined the effect of regulation on institutional investors' holdings through the lens of climate policy, such as the Paris Agreement (Bolton & Kacperczyk, 2020, 2021; Cao, Li, Zhan, Zhang, & Zhou, 2022; Monasterolo & de Angelis, 2020), and mandatory carbon disclosure law (Jouvenot & Krueger, 2021). While global climate policies may represent a shock to the overall awareness of environmental risks, it is unclear how individual firms or their polluting plants are impacted by such policies because they often do not have any enforcement mechanisms. Similarly, disclosure laws may not necessarily impose any costly emission restrictions on polluting firms. Nonattainment designations, on the other hand, are federally-enforced legally binding regulations that impose significant regulatory costs on polluting firms because they have a material impact on a firm's emission behavior (Greenstone, 2002, 2003).

Finally, this study makes an important contribution to the real impact of environmental regulations on the capital allocation in financial markets. The environmental economics literature has utilized county-level nonattainment designations to study the effect of environmental regulations on health outcomes (Bishop, Ketcham, & Kuminoff, 2022), industrial activity (Becker & Henderson, 2000; Greenstone, 2002; List, McHone, & Millimet, 2004; List, Millimet, Fredriksson, & McHone, 2003), housing prices (Bento et al., 2015; Chay & Greenstone, 2005; Grainger, 2012), employment (Curtis, 2020; Kahn & Mansur, 2013), labor reallocation (Walker, 2011, 2013), productivity (Greenstone, List, & Syverson, 2012; Shapiro & Walker, 2018), earnings (Isen, Rossin-Slater, & Walker, 2017), and pollution substitution (Gibson, 2019; Greenstone, 2003). To the best of our knowledge, we provide the first empirical analysis that uses nonattainment designations to show that environmental regulations have a material impact on the capital allocation of polluting firms in the financial markets.

2. Background on pollution and environmental regulations

The CAA requires the EPA to set NAAQS for six pollutants: carbon monoxide, nitrogen dioxide, ozone, sulfur dioxide, particulate matter, and lead. We focus on ozone because counties most often fail to meet NAAQS standards by exceeding ozone limits, rather than by violating the NAAQS for the other pollutants (Curtis, 2020). As a result, ozone offers a much larger treatment group of counties for our analyses.

Each year, the CAA also requires the EPA to designate each county either as being in attainment or out of attainment (nonattainment) with the NAAQS. A county can move from the attainment to the nonattainment designation in two ways. First, the county's ozone emissions can rise, pass the NAAQS threshold, and trigger the nonattainment designation. Second, the EPA can lower the NAAQS threshold, triggering the nonattainment designation for some counties. During our sample period, the EPA lowered the NAAQS threshold for ozone four times, as reported in Table IA.1 of the Internet Appendix.[1] As explained in the following section, we focus only on these four changes in NAAQS when evaluating the impact of the nonattainment designation on mutual funds' portfolio holdings.

For nonattainment counties, the EPA requires the state to submit a SIP (state implementation plan) and also implements its own requirements. SIPs indicate how the state will bring nonattainment counties back into compliance with NAAQS (US EPA, 2013). While SIPs may vary from state to state, they must follow EPA's guidelines and be approved by the EPA. Failure to submit and execute an acceptable SIP can result in federal sanctions, including withholding federal grants, penalties, and construction bans on new polluting establishments.

The EPA imposes regulatory restrictions on economic activity in noncompliant counties. The regulations require that any newly constructed large pollution sources or major modifications to existing large pollution sources satisfy the standard of "lowest achievable emission rate" (LAER). LAER requires the installation of the cleanest available technology, regardless of costs. Moreover, any emissions from new or expanding sources must be offset from an existing source located in the same county before commencing operations. For existing pollution sources in nonattainment counties, the EPA requires those sources to meet "reasonably available control technology" (RACT) standards, which are emission limits with minimal economic feasibility (US EPA, 2006).

The EPA also has the authority to bump up an existing nonattainment county from a lower

[1] In this table, the name of each ozone standard is based on the year in which the new NAAQS was proposed. The effective date is when the EPA actually implemented that standard.

classification to a higher one ("bump-up classifications") if the county fails to demonstrate an improvement in air quality by the given date as specified in the SIP. Bump-ups represent an increase in the regulation intensity since requirements on pollution abatement capital and emission offsets are increasing in stringency with respect to the classification. For example, a unit of emissions from new sources must be offset by more than a unit of emissions from existing sources in nonattainment counties classified as moderate or above (Sheriff, Ferris, & Shadbegian, 2019).

In attainment counties, plants face significantly less expensive environmental standards than those in non-attainment counties. New plants and major modifications to existing plants are subject to the installation of "best available control technology" (BACT). Under BACT, the EPA considers the technology's economic burden on the plant as the foremost priority in determining an acceptable emissions technology. As a result, large-scale investments in attainment counties typically involve less expensive pollution abatement equipment and the EPA does not require emissions offsets.

Taken together, the costs of operating plants that emit ozone differ across counties and among firms within the same county. On capital expenditures, the costs are lowest in attainment counties (BACT) and highest in nonattainment counties (LAER/RACT). Beyond capital expenditures, SIPs typically impose more costly regulatory burdens on plants operating in nonattainment counties, such as requirements to use materials and alter operating and maintenance procedures in ways that reduce emissions (Becker, 2005; Becker & Henderson, 2000, 2001). Regulatory intensity and hence operating costs can also differ across firms within nonattainment counties. For example, the EPA regulates plants operating closer to ozone monitors more intensely than those located further away, potentially boosting compliance costs (Auffhammer et al., 2009; Bento et al., 2015; Gibson, 2019). As another example, plants in nonattainment counties with pre-existing ozone operating permits tend to have lower risks of violating nonattainment standards (Walker, 2013), potentially reducing compliance costs. Therefore, the nonattainment designation not only triggers a discrete, "extensive margin" change in environmental regulations among all plants in nonattainment counties relative to those in attainment counties, but also triggers cross-plant, "intensive margin" changes in the intensity of environmental regulations, and potentially in operation costs within nonattainment counties. We exploit both the extensive and intensive margins triggered by the nonattainment designation.

2.1. Nonattainment designations as a research design

Existing studies show that nonattainment designations are effective at reducing pollution levels, and much of this reduction is a result of increased firm compliance because nonattainment designations are federally-enforced legally binding regulations for polluting plants (Chay & Greenstone, 2003; Henderson, 1996). Thus, our identification strategy uses nonattainment designations as exogenous shocks to local regulatory stringency to study how mutual funds adjust their holdings of polluting firms affected by such shocks.

A potential concern is that air pollution is driven by industrial activity, so counties that are designated nonattainment may correspond to those that have more underlying economic activities. To address this concern, our empirical design relies on nonattainment designations *induced* by discrete policy changes in the NAAQS threshold.[2] Over our sample period, the EPA revised downwards the NAAQS threshold four times.[3] Given an exogenous revision in the NAAQS threshold, many counties suddenly found themselves in nonattainment relative to the year prior, even if their ozone emissions did not change by all that much. Therefore, the switch to nonattainment is triggered by the lowering of the NAAQS threshold that defines noncompliance, as opposed to rising ozone emissions.

This regulatory design is illustrated in Figure 1. The figure shows the difference in the number of nonattainment counties between the current year and the previous year during the sample period 1991 to 2019. As can be seen, there are four peaks that coincide with the implementation of a revised NAAQS threshold, which leads to a large number of counties falling into nonattainment.[4] In between the peaks, counties move in and out of nonattainment designations due to changes in their ozone pollution level.[5] During this period, there are generally more counties redesignated to attainment rather than entering into nonattainment, suggesting that revisions to the NAAQS thresholds drive most of the nonattainment designations.[6] Thus, our empirical specificiations focus on the nonattainment

[2]We focus on four discrete changes in the NAAQS threshold. In chronological order, these include the 1-Hour Ozone (1979) standard effective on January 6, 1992, 8-Hour Ozone (1997) standard effective on June 15, 2004, 8-Hour Ozone (2008) standard effective on July 20, 2012, and 8-Hour Ozone (2015) standard effective on August 3, 2018. For more details, see Table IA.1 of the Internet Appendix.

[3]The revised thresholds are based on new scientific research that reflects the ongoing health effects of air pollution during that period of time (Gibson, 2019).

[4]Consistent with the findings of Curtis (2020), the revision that occurred on June 15, 2004 saw an additional 195 counties entering into nonattainment, which is the most out of all the revisions.

[5]It is very rare for a county to be designated as nonattainment for a second time once it has been redesignated to attainment.

[6]Nonattainment designations are fairly persistent; the mean duration of nonattainment for the sample of counties that we study is around 16 years. There is also substantial variation in the length of time that a county remains in nonattainment; some counties are redesignated to attainment after one or two years, while others (e.g., counties in Southern California) have been in nonattainment for over a decade.

designations that occurred during the four policy changes.

We further exploit this regulatory design to control for potential anticipation of nonattainment designations. Recently, Borochin et al. (2022) show that estimated market reactions in event studies may be biased downwards due to event anticipation. In our setting, attentive fund managers may be able to anticipate a county's nonattainment status by calculating the underlying ozone concentrations. For example, counties that have an ozone pollution level well above the NAAQS threshold are likely to be designated nonattainment, regardless of the revisions in thresholds. To account for event anticipation, we use a RDD to define an optimal "narrow" window around the NAAQS thresholds, which allows us to decompose nonattainment designations into an "unexpected" and "anticipated" component. We discuss this procedure in more detail in Section 4.2.

3. Data

3.1. Mutual funds

We collect our mutual fund data from the Center for Research in Security Prices (CRSP) Survivor-Bias-Free U.S. Mutual Fund Database. The holdings of mutual funds are obtained from Thomson Reuters mutual fund holdings, which is merged with CRSP mutual fund data using the MFLINKS files from the Wharton Research Data Services. Since most funds report their holdings every quarter, our analysis will be conducted at quarterly intervals. Our sample focuses on domestic actively managed equity mutual funds because we wish to identify deliberate portfolio rebalancing in response to nonattainment regulatory shocks.[7] Funds with multiple share classes are aggregated as a single fund, given that they have the same portfolio holdings. We apply a number of filters. The funds that have missing names in CRSP are deleted (Amihud & Goyenko, 2013; Cremers & Petajisto, 2009) and those with a total net asset value of less than $15 million are excluded from our sample (Elton, Gruber, & Blake, 2001). We also eliminate underdiversified funds with less than 10 stock holdings (Doshi, Elkamhi, & Simutin, 2015). Our final sample consists of 3,271 unique funds from 1991 to 2019.

3.2. Firms' ozone pollution

Firms' plant-level ozone pollution data comes from the EPA's TRI database. The TRI data file contains information on the disposal and release of over 650 toxic chemicals from more than 50,000 plants in the U.S. since 1987. Industrial facilities that fall within a specific industry (e.g., manufacturing, waste management, mining, etc), have ten or more full time employees,

[7]We exclude index, municipal bonds, balanced, sector, bond, and money market mutual funds.

and handle amounts of toxic chemicals above specified thresholds must submit detailed annual reports on their releases of toxins to the TRI. The TRI provides self-reported toxic emissions at the plant-level along with identifying information about the facility such as the plant's name, county of location, industry, and parent company's name.[8] Internet Appendix Table IA.2 lists the three-digit NAICS industries in TRI that are included in our sample. Similar to Akey and Appel (2021), the most common industries are chemical manufacturing (12.97% of sample), fabricated metal product manufacturing (12.64%), and transportation equipment manufacturing (8.22%).

Within any nonattainment county, a polluting plant is regulated only if it emits the specific criteria air pollutant for which the county is in violation. Since we only focus on ozone, we use the emissions data in TRI to classify whether a facility is a polluter of ozone.[9] In any given year, a facility is labeled as an ozone plant if it emits chemicals that are classified as volatile organic compounds or nitrogen oxides, both precursors to ozone formation.[10] Although the TRI data provides information on chemical emissions through the ground, air and water, we only consider emissions through the air (measured in pounds) because the NAAQS only regulates air emissions. Internet Appendix Figure IA.1 shows the fraction of plants that are labeled as ozone polluters across major industries in nonattainment counties. Even within two-digit industry NAICS codes, there is a considerable amount of variation in the fraction of plants that are classified as ozone polluters. Since our paper examines fund holdings of public stocks, we only use the facilities that are owned by public companies in TRI. To obtain parent companies' financial and stock price information, we manually match the TRI parent company names to those in Compustat and CRSP. The final sample consists of 1,625 unique firms from 1991 to 2019.

3.3. Environmental regulation events

We examine three types of environmental regulation at the county-level: i) nonattainment designations; ii) bump-up classifications; and iii) redesignations to attainment. We manually

[8] While the TRI data are self-reported, the EPA regularly conducts quality analyses to identify potential errors and purposefully misreporting emissions can lead to criminal or civil penalties (Xu & Kim, 2022). Additionally, studies have shown that the aggregate effects of reporting errors appear to be marginal (Bui & Mayer, 2003; US EPA, 1998). Nonetheless, to minimize reporting errors due to changes in reporting requirements in the early years of TRI data collection (De Marchi & Hamilton, 2006), we follow Gibson (2019) and exclude the period 1987 to 1990 from our analysis.

[9] We use the mapping from TRI chemicals to CAA criteria pollutants from Greenstone (2003). However, additional chemicals have been introduced into the TRI since the creation of the mapping. Thus, we contacted the EPA and also hired a Ph.D. chemist in atmospheric science to classify the remaining chemicals.

[10] Ozone is not directly emitted by plants, but rather formed through chemical reactions in the atmosphere. Henceforth, we refer to emitters of ozone precursors as ozone emitters/polluters.

search the Federal Register and hand-collect the effective dates of every event. Since a firm can own many plants located across multiple counties, we consider a firm to be exposed to nonattainment designations if it owns facilities that operate in the counties designated nonattainment.[11] We require facilities to have no changes in parent firm ownership from the prior year to the event year and have non-missing ozone emissions data in TRI in the prior year. Our final sample of events from 1991 to 2019 consists of 1,286 nonattainment designation county-event-quarters involving 896 firms, 262 bump-up county-event-quarters involving 363 firms, and 472 attainment redesignation county-event-quarters involving 503 firms.

3.4. Monitor-level ozone concentration

We obtain monitor-level ozone concentrations from the Air Quality System (AQS) database maintained by the EPA. For each ozone monitor, the database includes ozone concentration readings and the county location of the monitor. We use these ozone concentrations to calculate "design values" (DV), which are the primary statistics that the EPA uses to determine whether a county is in compliance with the NAAQS. Specifically, counties with DVs that are above the relevant threshold are designated nonattainment, while those below the threshold remain in attainment. Although other factors such as a county's geography and meteorology may also contribute to nonattainment status, noncompliance based on DVs is the key determinant of nonattainment.[12] The rules that we use to calculate the DVs for different ozone standards as well as the relevant thresholds are given in Table IA.1 of the Internet Appendix. We use the DVs to decompose nonattainment designations into an anticipated component and an unexpected component. Although the DVs are publicly released by the EPA annually, they only represent snapshots in time and may not correspond to the information publicly available to fund managers at the time of nonattainment designations.[13] Thus, we tailor the calculation of the DVs using time periods that mimics, as close as possible, the information available to fund managers at the time of nonattainment designations.[14]

[11]Bump-ups and redesignation to attainment events are aggregated at the firm-level in a similar manner.

[12]See `https://www.epa.gov/ozone-designations/ozone-designations-guidance-and-data#B` for more details on other contributing factors. In our communications with the EPA, we were informed that DVs are the primary determinant of a county's nonattainment status, with the other factors being used to determine the geographic boundaries of the nonattainment area. After manually verifying each county's nonattainment designation in the Federal Register, we find that approximately 90% of all nonattainment designations are based on DVs and only 10% mention the influence of other factors. As we will show later in Section 4.2.1, counties with a DV in violation of the NAAQS threshold has a 65% higher probability of being designated nonattainment.

[13]The EPA may also retroactively change the design values after the date of publication for a variety of reasons, including revisions due to data being influenced by exceptional events and monitoring issues.

[14]For example, the rule used to calculate the DVs for the 8-Hour Ozone (1997) standard effective on June 15, 2004 is the three-year rolling average of the fourth highest daily ozone reading in each year. Thus, we use

3.5. Variables

3.5.1. Outcome and key explanatory variables

For the main outcome variable, each quarter, we calculate the weight (in percentage points) of a given stock in a given mutual fund's portfolio as the dollar holdings of a stock divided by the total dollar holdings of all stocks in the mutual fund's portfolio.

The main explanatory variables are defined as follows. Since a firm can own many plants operating across multiple attainment and nonattainment counties, we capture the exposure of a firm to nonattainment designations by constructing the variable *NA ratio*, which equals to the number of polluting plants located in nonattainment counties for a given firm divided by the total number of polluting plants owned by the firm. This variable is constrained between zero and one, and a higher value indicates a greater exposure of a firm to nonattainment designations. However, not all polluting plants emit ozone and the extent to which a firm is regulated depends on how reliant it is on ozone emissions. To measure the dependence of a given firm on ozone emissions, we calculate the variable *Ozone ratio*, which equals to the ozone air emissions for a given plant as a proportion of the plant's overall air emissions, averaged across all plants owned by a given firm. This variable is also constrained between zero and one, and a higher value indicates a greater proportion of the firm's pollution is ozone.

Since bump-ups and attainment redesignations are both conditional on nonattainment status, we measure a firm's exposure to bump-ups by constructing the variable *Bump ratio*, which equals to the number of polluting plants located in nonattainment counties experiencing bump-ups for a given firm divided by the total number of *nonattainment* polluting plants owned by the firm. Similarly, to capture a firm's exposure to attainment redesignations, we define the variable *Redesig ratio*, which equals to the number of polluting plants located in counties redesignated to attainment for a given firm, divided by the total number of *nonattainment* polluting plants owned by the firm.

3.5.2. Control variables

Following Alok et al. (2020), control variables for fund characteristics include fund size (*ln(Fund size)*), defined as the natural logarithm of one plus the sum of total net assets (TNA) of all fund classes; fund quarterly return (*Fund returns*), calculated as the weighted average of returns over the share classes, using individual share classes' total net assets as the weight; weighted average expense ratios (*Expense ratio*); weighted average turnover ratios (*Turnover ratio*); and fund flow

ozone concentration data from 2001 to 2003 in calculating DVs for nonattainment designations associated with the 8-Hour Ozone (1997) standard.

in quarter t (*Net flow*), defined as $100 \times (TNA_t - (1 + Fund\ returns_t) \times TNA_{t-1}) / TNA_{t-1}$.

Following Kang and Stulz (1997), control variables for firm characteristics that are potential determinants of fund holdings include the natural logarithm of market capitalization (*ln(Size)*); the natural logarithm of book-to-market ratio (*ln(BM)*); return on assets (*ROA*), calculated as net income divided by total assets; debt to assets ratio (*Leverage*), calculated as total liabilities divided by total assets; sales growth (*Sales growth*), defined as the percentage quarterly change in firm sales as compared to the same fiscal quarter of the prior year; price momentum (*Momentum*), defined as the cumulative 12-month return of a stock, excluding the immediate past month; and quarterly stock returns (*Stock returns*).

3.6. Descriptive statistics

After taking the intersection of various data sources, the final sample comprises 3,644,290 fund-stock-quarter observations between 1991 to 2019. Panels A and B of Table 2 present summary statistics on the fund and firm level variables, respectively. A full list of the variables used in this paper and their data sources can be found in Table A.1 in Appendix A. On average, the weight of a stock in a mutual fund's portfolio is 1.017%. An average fund in our sample has a size of $151.47 million, an expense ratio of 0.01, a turnover ratio of 0.87, a fund flow of -0.083%, and a quarterly return of 0.80%.

The mean of *NA ratio* implies that during nonattainment designations, roughly 34.1% of a firm's polluting plants are affected. Of this amount, approximately 14.3% of a firm's polluting plants are exposed to unexpected nonattainment designations, while 19.7% are exposed to anticipated nonattainment designations. The mean for *Ozone ratio* indicates that for the typical firm in our sample, across all polluting plants, about 34.3% of total air emissions are ozone. Both *NA ratio* and *Ozone ratio* have sizable standard deviations, indicating that there is substantial variation in the exposure of firms to nonattainment designations and their dependence on ozone emissions. During bump-up classifications, a typical firm has 40.8% of its polluting plants in nonattainment counties bumped-up to a more severe classification. When there is a redesignation to attainment, roughly 36.7% of a firm's nonattainment plants are affected.

Table 1 reports county-level characteristics by state. Pennsylvania and California have the two highest number of nonattainment counties, followed by Michigan and Virginia. Most states have counties that were in nonattainment at least once during the sample period; only 11 states were never designated nonattainment. In terms of redesignations to attainment, 20 states have all of their nonattainment counties redesignated back to attainment, while 8 states have never experienced an attainment redesignation event during our sample period. The average length of time that counties have been in nonattainment ranges from zero to 28 years. There is also substantial variation in the county-level DVs across states.

4. Empirical strategy

4.1. Difference-in-differences

In this section, we outline our empirical methodology to test the rational hypothesis. We examine funds' portfolio responses to three types of environmental regulation: nonattainment designations, bump-up classifications, and attainment redesignations.

Our empirical model for nonattainment designation events is a difference-in-differences specification. We focus on a five-quarter window centered on the nonattainment designation quarter. For instance, if the nonattainment designation occurs in quarter Q, then $Q-2$ and $Q-1$ are the pre-nonattainment designation quarters, while Q, $Q+1$, and $Q+2$ are the post-nonattainment designation quarters. We collapse the dataset into one observation for the pre-period and one for the post-period. We do this by taking average values of the fund's portfolio weight in a given stock for the two quarter period before the nonattainment designation and for the three quarter period after the nonattainment designation. This significantly reduces the number of observations and will ensure that we do not understate the standard errors.[15]

The outcome variable of interest is the change (post minus pre) in portfolio weights. The unit of observation in our analysis is a fund-firm-event quarter. Formally, our baseline specification is as follows:

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

for fund m, stock s, and quarter t. The dependent variable, $\Delta w_{m,s}$, is the change in the average weights (in percentage points) of a given stock in a given mutual fund's portfolio. $NA\ ratio_{s,t}$ is measured in the quarter of the nonattainment designation, while $Ozone\ ratio_{s,t-1}$ is measured in the period before the nonattainment designation to reflect the emissions data available to fund managers at the time of nonattainment designations. $X_{s,t-1}$ and $X_{m,t-1}$ are vectors of lagged firm-level and fund-level control variables, respectively, measured at the end

[15] OLS estimates tend to under-estimate standard errors in difference-in-differences estimates with large time series (Bertrand, Duflo, & Mullainathan, 2004). Collapsing the data into one pre- and post-observation for each group ensures the estimation is more reliable (Petersen, 2009; Roberts & Whited, 2013).

of quarter $t-1$.

We include fund fixed effects (μ_m) and stock fixed effects (τ_s) that absorb all time-invariant differences across funds and stocks, respectively. Finally, ρ_t are year-quarter fixed effects that control for aggregate macroeconomic shocks. We also estimate two variants of the baseline specification based on more stringent fixed effects. The first version includes fund $\times$ stock fixed effects, which ensures that the portfolio response to ozone pollution during nonattainment designations is identified after accounting for persistent preference differences by fund managers on ozone-polluting firms (Hong & Kostovetsky, 2012). The second version adds fund $\times$ year-quarter fixed effects, which controls for time-varying cross-fund factors.

The coefficient of interest is β_3, which captures the extent to which mutual funds adjust their portfolio holdings to hedge against nonattainment regulations, based on a stock's exposure to nonattainment designations (*NA ratio*) and dependence on ozone emissions (*Ozone ratio*). The rational hypothesis predicts that β_3 is negative, indicating that heavy ozone-polluting firms exposed to nonattainment designations are underweighted more in funds' portfolios. We modify our specification accordingly when examining portfolio response to the other events—bump-up classifications and attainment redesignations—while maintaining the basic setup. These regression specifications are explained in complete detail when we present the results.

4.2. Event anticipation

Since a county's monitored ozone pollution levels are observable, attentive fund managers may be able to anticipate a county's nonattainment status. To account for event anticipation, we decompose nonattainment designations into an anticipated component and an unexpected component based on county-level DVs. The intuition is that counties with a DV far above the NAAQS threshold are likely to be designated nonattainment, no matter what the threshold is revised to. Likewise, counties with a DV far below the threshold are likely to remain in attainment, independent of pending changes in the threshold. The question then becomes how far above or below the NAAQS threshold can one reasonably predict a county's designation status.

The idea underlying our approach is that nonattainment designations are a random outcome in an arbitrarily small interval around the NAAQS threshold; for example, whether a county is in compliance with a DV slightly below the NAAQS threshold or in violation with a DV slightly above the threshold is arguably random. Thus, using RDD to exploit the sharp increase in nonattainment probability when a county's DV moves from below to above the

NAAQS threshold, we are able to estimate an optimal "bandwidth" centered on the NAAQS threshold that determines the region where ozone concentrations are as good as randomly assigned, and hence, unpredictable.

Formally, we perform the RDD by using a nonparametric, local linear estimation. Small neighborhoods on the left- and right-hand sides of the NAAQS threshold are used to estimate discontinuities in nonattainment probability. We follow Calonico, Cattaneo, and Titiunik (2014) to derive the asymptotically optimal bandwidth under a squared-error loss. The choices of the neighborhood (bandwidth) are data-driven (determined by the data structure) and different across samples and variables. By choosing the optimal bandwidth to the left and right of the threshold, we only include observations in the estimation if the absolute difference between the DV for that observation and the threshold is less than the bandwidth. The local linear regression model can therefore be specified as

$$NA_{c,t+1} = \alpha + \beta Noncompliance_{c,t} + \phi f(R_{c,t}) + \varepsilon_{c,t+1} \tag{2}$$

for county c and year t. $NA_{c,t+1}$ is a dummy variable equal to one if county c is designated nonattainment in year $t+1$, and zero otherwise. $Noncompliance_{c,t}$ is a dummy variable equal to one if county c's DV is in violation of the NAAQS threshold in year t, and zero otherwise. $R_{c,t}$ is the centered DV (i.e., the running variable in RDD parlance), defined as the difference between the DV of county c in year t and the NAAQS threshold. Negative (positive) values indicate that the county is in compliance with (violation of) the NAAQS threshold. We use local linear functions in the running variable with rectangular kernels as represented by $f(R_{c,t})$. Since treatment assignment is at the county-level, standard errors are clustered by county and bias-corrected as discussed in Calonico et al. (2014).

We conduct tests that support the identifying assumptions of the RDD specification in Section IA of the Internet Appendix. In short, we do not find any evidence that counties strategically manipulate their DVs to be right below the NAAQS threshold, nor do we find any statistically significant differences in preexisting firm characteristics in the narrow neighborhood around the threshold between those operating polluting plants in counties that are in violation of the NAAQS thresholds and those operating in counties that are in compliance.

4.2.1. Estimation results

We present the estimation results of Equation (2) in Table IA.3 of the Internet Appendix. The coefficient estimate on β captures the discontinuity at the NAAQS threshold and is equal to the difference in the probability of nonattainment between counties that marginally violate the NAAQS threshold and those that marginally comply with the threshold.[16] In column (1), we use the full sample of nonattainment designations based on revisions in the NAAQS threshold across all four ozone standards. Noncompliance based on DVs leads to an increase in the probability of nonattainment by roughly 65%, indicating that DVs are the main determinant of nonattainment status. Similar results are obtained when using the subsample of nonattainment designations based on revisions in the NAAQS threshold for each individual ozone standard separately.

Internet Appendix Table IA.3 also provides the estimates of the optimal bandwidth. The bandwidth estimate of 0.009 in column (1) implies that for the full sample of nonattainment designations, counties with DVs that are within 0.009 ppm of the NAAQS threshold have ozone concentration levels that are as good as randomized. Counties with DVs that exceed the threshold by more than 0.009 ppm are considered to be far "enough" *above* the threshold that they will most likely be designated nonattainment. Similarly, counties with DVs that are below the threshold by more than 0.009 ppm are considered to be far "enough" *below* the threshold that they will most likely remain in attainment.

4.2.2. Unexpected and anticipated nonattainment designations

Figure 2 illustrates how we use the optimal bandwidth estimate of 0.009 to decompose nonattainment designations into an unexpected and anticipated component. The figure plots the probability of nonattainment against the centered DVs using the full sample of nonattainment designations based on revisions in the NAAQS threshold across all four ozone standards. Each dot in the figure represents the average of $NA_{c,t+1}$ using integrated mean squared error optimal bins following Calonico et al. (2014). As can be seen, the probability of nonattainment appears to be a continuous and smooth function of the centered DVs everywhere except at the NAAQS threshold, where there is a discontinuous jump upwards.

We define the region within the bounds of the optimal bandwidth as the unpredictable region. Within this region, changes in the probability of nonattainment are attributable to random fluctuations in the underlying DVs on either side of the threshold, and hence unpredictable. The region to the right of the right-endpoint of the optimal bandwidth is defined as the predicted nonattainment region. Similarly, the region on the left of the left-

[16] Following Curtis (2020), the point estimates on β and optimal bandwidth selection are covariate-adjusted by including additional county-level covariates such as the natural logarithm of one plus the employment levels in a given county, a given county's NOx emissions to employment ratio, the change in a given county's employment levels, and a dummy variable equal to one if the county is located in a MSA.

endpoint of the optimal bandwidth is defined as the predicted attainment region. Note that most counties in the predicted nonattainment region tend have a nonattainment probability of one, while some counties in the predicted attainment region may have small, but non-zero nonattainment probabilities. This observation is consistent with the fact that although counties with ozone concentrations that are considerably higher than the threshold will most certainly be designated nonattainment, those with ozone concentrations that are much lower than the threshold may still be designated nonattainment based on non-DV factors such as geography and meteorology.

To decompose nonattainment designations into an unexpected and anticipated component, we compare investors' predictions based on DVs prior to the designation and the actual realization of a county's designation status. We define anticipated nonattainment designations to be those counties that reside in the predicted nonattainment region and are designated nonattainment subsequently. Thus, anticipated nonattainment designations correspond to the counties where investors' predictions of nonattainment align with realizations. We define unexpected nonattainment designations to be those counties that either: i) reside in the unpredictable region and are designated nonattainment subsequently; or ii) reside in the predicted attainment region and are designated nonattainment subsequently. The first part captures the inherent unpredictability of nonattainment status due to random fluctuations in the DVs in the narrow window around the threshold, while the second part captures the cases where investors' predictions of nonattainment differ from realizations due to other unobservable non-DV factors contributing to the nonattainment designation.[17]

Using this decomposition, we find that out of a total of 1,286 nonattainment designation event-quarters, 935 are classified as unexpected nonattainment designations, while 351 are considered anticipated. Among the 935 unexpected nonattainment designations, 792 consists of counties that reside in the unpredictable region, while only 143 are in the predicted attainment region. Thus, the vast majority of all unexpected nonattainment designations are due to unpredictability in the underlying ozone concentrations, rather than other non-DV factors. This result reinforces the fact that noncompliance based on DVs is the key determinant of nonattainment. At the firm-level, we construct the variables *Unexp. NA ratio* and *Antic. NA ratio* to be equal to the number of polluting plants located in unexpected and anticipated nonattainment counties for a given firm divided by the total number of polluting plants owned

[17]These non-DV factors are also "unexpected" because they are unobservable from the investors' perspective. For example, a county may have a DV that is in compliance with the NAAQS threshold, but may still be designated nonattainment if winds or other geographical conditions causes it to contribute to the ozone levels of other neighboring counties.

by the firm, respectively.

5. Results

5.1. Portfolio response to nonattainment designations

5.1.1. Changes in portfolio weights

We begin our empirical analysis by examining changes in portfolio weights of ozone emitting firms exposed to nonattainment designations. The rational hypothesis predicts that funds underweight heavy ozone-polluting firms exposed to nonattainment designations as a hedge against regulatory risk, since the cash flows of these firms are negatively impacted by the nonattainment regulatory shock. We present the estimation results of Equation (1) in Table 3. In column (1), we present the results without control variables. Columns (2) and (3) separately include firm and fund control variables, respectively. Column (4) includes both sets of control variables. Regardless of the specification, the coefficients on *NA ratio* × *Ozone ratio* are negative and statistically significant. Consistent with the predictions of the rational hypothesis, we find that funds reduce portfolio weights of heavy ozone-polluting stocks that are also heavily regulated due to nonattainment designations.

To enable an economic interpretation of the magnitude of the underweighting, we revert Equation (1) back to a triple difference-in-differences specification and include a *Post NA* dummy variable which equals to one for the post-nonattainment designation quarters, and zero otherwise.[18] The coefficient estimate on the triple interaction term *NA ratio* × *Ozone ratio* × *Post NA* is -0.056% and statistically significant. For the median fund in our sample, a one standard deviation increase in *NA ratio* and *Ozone ratio* leads to a sizable 1.17% drop in the dollar value of such stocks.[19] In a more extreme example, the reduction in the dollar value of a firm that operates all ozone plants and becomes fully exposed to nonattainment designations is a staggering 9.8% compared to one that operates only non-ozone plants without any exposure to nonattainment designations.[20]

Next, we utilize more stringent fixed effects. Column (5) of Table 3 uses fund × stock fixed effects, column (6) uses fund × year-quarter fixed effects, and column (7) includes both sets

[18]The dependent variable in this analysis is the weight in levels and not the difference. The estimation results are reported in Internet Appendix Table IA.5.

[19]The median size of a mutual fund portfolio in the pre-nonattainment period is \$245.24 million. The median dollar value invested by funds in stocks with a non-zero value of *NA ratio* and *Ozone ratio* is \$1.4 million. So, a one standard deviation increase in *NA ratio* and *Ozone ratio* combined with a reduction in overall portfolio weight of 0.056% translates into $0.056\% \cdot 0.358 \cdot 0.334 \cdot 245.24/1.4 \approx 1.17\%$ reduction in the dollar value of a stock holding.

[20]$0.056\% \cdot 245.24/1.4 \approx 9.8\%$.

of fixed effects.[21] Across all three columns, the coefficients on *NA ratio* × *Ozone ratio* remain negative and statistically significant. These results indicate that our main findings continue to hold after controlling for unobservable, time-varying fund characteristics and differences in fund managers' preferences to hold ozone-polluting stocks.

Also in line with the predictions of the rational hypothesis, we find that the coefficients on *NA ratio* and *Ozone ratio* in Table 3 are all positive and statistically significant. For example, the positive coefficient on *NA ratio* implies that funds reallocate holdings toward firms that are exposed to nonattainment designations, but operate only non-ozone plants. Likewise, the positive coefficient on *Ozone ratio* implies that funds reallocate holdings toward firms that operate ozone plants, but are located in attainment counties. Both types of firms are unaffected by nonattainment designations, and thus, are overweighted because they serve as appropriate hedges against nonattainment regulatory risk.

5.1.2. Temporal dynamics of portfolio weights

We now examine the temporal dynamics of the changes in portfolio weights around nonattainment designations to see if there are any pre-trends in the data. The absence of pre-trends (differential response before nonattainment designations) in portfolio weights is a necessary condition for the validity of our difference-in-differences setting. We revert Equation (1) back to a triple difference-in-differences specification and include a set of dummy variables that represent the quarters relative to the nonattainment designation event quarter, *Post NA(k)* where k ranges from -4 to $+4$, and their corresponding interaction terms with *NA ratio* and *Ozone ratio*. We extend the window from four quarters prior to four quarters after a nonattainment designation to better observe the presence of any pre-trends and to see how long the underweighting persists for. The quarter before the nonattainment designation is the omitted category.

Figure 3 reports the point estimates (solid line) and 95% confidence intervals (dashed lines) of the coefficients for the interaction terms *NA ratio* × *Ozone ratio* × *Post NA(k)*. There is no significant difference in portfolio weights of heavy ozone-polluting stocks exposed to nonattainment regulations compared to less-affected stocks before the nonattainment designation. Then, starting in the event quarter, funds begin to underweight heavy ozone-polluting stocks with large exposures to nonattainment designations. The underweighting continues progressively until the fourth quarter post event, whereby we begin to see a weakening of the magnitude of the underweighting. This observation is consistent with the interpretation

[21] In columns (6) and (7), the fund control variables are absorbed by the fund × year-quarter fixed effects.

that the covariance between expected changes in the cash flows of ozone-polluting firms and the nonattainment regulatory shock is most negative during the three quarters post event, when the market is still impounding the costs of nonattainment regulation into ozone-polluting firms' stock prices. However, the covariance becomes less negative as time passes because the market has efficiently incorporated the costs fully into firms' stock prices, resulting in a weakening of the magnitude of the underweighting.

5.1.3. Unexpected and anticipated nonattainment designations

In this section, we decompose portfolio responses to nonattainment designations into an unexpected and anticipated component. Given a nonattainment designation, funds should only be hedging against the unexpected component since any portfolio changes spurred by the anticipated component should have been incorporated before the nonattainment designation event. To test this, we replace *NA ratio* and its corresponding interaction terms in Equation (1) with *Unexp. NA ratio* and *Antic. NA ratio.*

The results are reported in Table 4. Across all specifications, only the coefficients on *Unexp. NA ratio* × *Ozone ratio* are negative and statistically significant, while those on *Antic. NA ratio* × *Ozone ratio* are statistically insignificant and considerably smaller in magnitude. These results indicate that funds are only underweighting those ozone-polluting stocks with plants located in counties experiencing unexpected nonattainment designations. For the non-interaction terms *Unexp. NA ratio* and *Antic. NA ratio*, only the coefficients on the former are positive and statistically significant, implying that funds only reallocate holdings toward firms operating non-ozone plants in unexpected nonattainment counties.

The insignificance of funds' portfolio response to the anticipated component of nonattainment designations provides additional support for the rational hypothesis. In particular, unexpected nonattainment designations are those where funds' predictions differ from realizations, hence, these unexpected nonattainment designations reveal new information on how firms' cash flows will covary with the nonattainment regulatory shock, which has not yet been predicted by the market. Consequently, funds hedge against these unexpected cash flow shocks by underweighting heavy ozone-polluting stocks operating in unexpected nonattainment counties. Anticipated nonattainment designations, on the other hand, are those where funds' predictions of nonattainment status are in line with realizations and so there is relatively little new information on cash flows revealed from these shocks. Thus, any hedging adjustments in response to anticipated nonattainment designations should have occurred before the actual designation event.

5.1.4. *Heterogeneous portfolio responses to nonattainment designations*

We now explore possible heterogeneity in the changes in portfolio weights to nonattainment designations. Specifically, we examine various firm characteristics that we predict to impose additional regulatory costs during nonattainment designations, and hence, lead to a more negative shock to cash flows. We also examine various fund characteristics that we predict to increase fund managers' propensity to hedge against nonattainment regulatory risk. Our empirical specification augments the decomposed version of Equation (1) with a variable Z that refers to a set of firm and fund characteristics measured in the quarter before the nonattainment designation and their corresponding interactions. Our focus is on the triple interaction terms *Unexp. NA ratio* $\times$ *Ozone ratio* $\times Z$ and *Antic. NA ratio* $\times$ *Ozone ratio* $\times Z$ that represent the differential effects of a particular characteristic on the underweighting of heavy ozone-polluting firms exposed to unexpected and anticipated nonattainment designations, respectively.

We begin by examining whether a firm owns an ozone operating permit. These operating permits are issued by the EPA and specifies the amount and type of pollutants that the polluting plants of a given firm is permitted to emit. Given a nonattainment designation, heavy ozone-polluting firms that do not own any ozone operating permits have a greater risk of violating nonattainment regulations (Walker, 2013), and hence, could potentially incur greater regulatory costs. In Figure 6, we define the variable *No ozone permit* to be a dummy variable equal to one if a given firm does not have an ozone operating permit, and zero otherwise.[22] We plot the point estimates and 95% confidence intervals of the coefficients for the unexpected (in black) and anticipated (in blue) components in the first two rows. In line with the predictions of the rational hypothesis, we find that heavy ozone-polluting firms without ozone operating permits that are exposed to unexpected nonattainment designations are underweighted more by funds, consistent with the fact that such firms experience a more negative shock to their cash flows. In contrast, the anticipated component is not statistically significant at any conventional significance levels.

Next, we consider the average distance of a firm's plants to the closest nonattainment monitor.[23] Given a nonattainment designation, firms that operate ozone emitting plants located close to nonattainment monitors are regulated more intensely than those located further away, since regulatory effort is localized in the areas surrounding nonattainment monitors (Auffhammer et al., 2009; Bento et al., 2015; Gibson, 2019). Thus, firms with plants

[22]We obtain plant-level permit data from EPA's Integrated Compliance Information System for Air (ICIS-Air) database

[23]A nonattainment monitor is defined to be a monitor that violates the NAAQS ozone standards.

that are located close to nonattainment monitors are subject to greater regulatory costs, leading to a more negative shock to their cash flows. In Figure 6, we define the variable *Close NA monitor* to be a dummy variable equal to one if the average distance between the polluting plants of a given firm to the closest nonattainment monitor is below the median, and zero otherwise. We find that firms operating ozone emitting plants closer to nonattainment monitors are underweighted more only for unexpected nonattainment designations.

Lastly, we distinguish between young and old plants. Becker and Henderson (2000) find that newer plants bear the brunt of nonattainment regulations because they are subject to costly LAER requirements, while older plants are grandfathered and escape regulation until they expand operations.[24] In particular, Becker and Henderson (2001) estimate that total compliance costs are 17.7% higher for young ozone emitting plants between zero and five years of age in nonattainment counties relative to similar plants in attainment counties, while the difference for older ozone emitting plants beyond five years of age is considerably lower at 9.5%. Following Becker and Henderson's (2001) definition, we define *Young plant* to be a dummy variable equal to one if the average plant age of a given firm is between zero and five years, and zero otherwise.[25] In Figure 6, we see that firms operating mostly young ozone emitting plants in unexpected nonattainment counties are underweighted more, consistent with these firms experiencing a greater negative shock to their cash flows.[26]

In terms of fund characteristics, we first examine fund size based on TNA. Small funds are likely to be overinvested in local stocks, resulting in excessively risky portfolios (Pool et al., 2012). Thus, small funds may have a greater incentive to hedge against nonattainment regulatory shocks, which leads to more underweighting of ozone-polluting stocks. In Figure 6, we define the variable *Small fund* to be a dummy variable equal to one for funds with a fund size below the median, and zero otherwise. Consistent with our predictions, we find that small funds underweight heavy ozone-polluting stocks exposed to unexpected nonattainment designations more than large funds, while no such underweighting is observed for anticipated nonattainment designations.

[24]Although younger plants may save on certain costs in terms of net present value since they do not need to renew their equipment as quickly as older plants, they face more "immediate" costs given a nonattainment designation. For example, older plants may already have RACT in place (thus saving on capital expenditures), while younger plants may need to implement RACT. Similarly, older plants may already have maintenance procedures in place to reduce emissions, while younger plants may not.

[25]The first year a plant appears in the TRI database is not necessarily its first year of operation, since a plant only reports to TRI if it meets the reporting requirements. Thus, to compute the age of a given plant, we use the first year of operation of a given facility in the National Establishment Time-Series (NETS) database.

[26]The standard errors for the point estimate is higher than those of the other characteristics. This could be because there is some noise in capturing cost differentials using the *Young plant* variable since cost differentials still exist between older plants in nonattainment and attainment counties, albeit smaller in magnitude.

We also examine a fund's concentration of stock holdings. Underdiversified funds may be particularly sensitive to temporary shocks stemming from nonattainment designations because of their higher idiosyncratic risks (Kacperczyk et al., 2005), which may lead to more underweighting of ozone-polluting stocks. We use two measures for fund portfolio diversification: the number of stocks held in the portfolio and the Herfindahl-Hirschman index (HHI), calculated based on the weights allocated to each stock in a given fund's portfolio. In Figure 6, *Low # stocks* is a dummy variable equal to one for funds with the number of stocks below the median, and zero otherwise, and *High HHI* is a dummy variable equal to one for funds with HHI concentration above the median, and zero otherwise. For both measures, we see that the underweighting of heavy ozone-polluting stocks exposed to unexpected nonattainment designations is stronger for more concentrated funds.

5.2. Portfolio response to bump-up classifications

We now explore changes in portfolio weights to bump-up classifications. Bump-ups increase the intensity of regulation in already nonattainment counties. Thus, heavy ozone-polluting firms operating plants in nonattainment counties facing bump-ups experience even greater regulatory costs when compared to initial nonattainment designations. Under the rational hypothesis, we expect funds to hedge against the regulatory risk induced by bump-ups by underweighting firms that are heavy polluters of ozone and operate a large fraction of plants in nonattainment counties experiencing bump-ups.

We focus on a five-quarter window centered on the bump-up classification quarter and estimate the following specification:

$$\Delta w_{m,s} = \beta_0 + \beta_1 Bump\ ratio_{s,t} + \beta_2 Ozone\ ratio_{s,t-1} + \beta_3 Bump\ ratio_{s,t} \times Ozone\ ratio_{s,t-1} + X_{s,t-1} + X_{m,t-1} + \mu_m + \tau_s + \rho_t + \varepsilon_{m,s,t} \tag{3}$$

for fund m, stock s, and quarter t. The dependent variable is the change in the average weights (in percentage points) of a given stock in a given mutual fund's portfolio during the post-bump-up quarters relative to the pre-bump-up quarters. Since bump-ups are conditional on nonattainment status, *Ozone ratio* is defined as the ozone air emissions for a given plant as a proportion of the plant's overall air emissions, averaged across all *nonattainment* plants owned by a given firm. $X_{s,t-1}$ and $X_{m,t-1}$ are vectors of lagged firm-level and fund-level control variables. μ_m, τ_s, and ρ_t are fund, stock, and year-quarter fixed effects, respectively. The coefficient of interest is β_3, which captures the extent to which mutual funds underweight heavy ozone-polluting firms operating plants in nonattainment counties that are exposed to bump-ups.

We present the estimation results of Equation (3) in Panel A of Table 5. Across all specifications of fixed effects, the coefficients on *Bump ratio* × *Ozone ratio* are negative and statistically significant, indicating that funds underweight heavy ozone-polluting firms exposed to bump-ups. The magnitude of the underweighting is also economically meaningful since for the median fund in our sample, it corresponds to a 1.58% drop in dollar value given a one standard deviation increase in *Bump ratio* and *Ozone ratio*.[27] Similar to our results on nonattainment designations, we find that funds reallocate holdings toward stocks that are not affected by bump-ups and hence do not experience any negative shocks to their cash flows. Specifically, the coefficients on *Bump ratio* and *Ozone ratio* are both positive and statistically significant, indicating that funds hedge against bump-up regulatory shocks by overweighting firms that are exposed to bump-ups, but operate only non-ozone plants, and firms that operate ozone plants, but are not exposed to bump-ups.

We also verify that there are no pre-trends driving our results. In Figure 4, we examine the dynamics of portfolio weights (levels) around bump-ups. Our focus is on the four quarters prior to four quarters after a bump-up using the variable *Post Bump(k)*, where k ranges from -4 to $+4$, defined as time dummies that represent the quarters relative to the bump-up event quarter. We do not find any evidence of a differential response in portfolio weights before the bump-up. Coincident with the event quarter, however, we observe a sharp decrease in portfolio weights, which continues until the fourth quarter.

Next, we decompose the change in portfolio weights in response to bump-ups into an unexpected and anticipated component following the same procedure in Section 4.2.2. Nonattainment counties that do not improve their DVs to be below the NAAQS threshold by the attainment deadline set forth in the SIP are likely to be bumped up to a higher classification. Thus, attentive fund managers may anticipate a bump-up if they closely track the DVs of the county over time. Estimating a similar RDD specification to that of Equation (2), except with the dependent variable as a dummy variable equal to one if a given county experiences a bump-up, and zero otherwise, yields an optimal bandwidth estimate of 0.013. We define

[27] Reverting Equation (3) to a triple difference-in-differences specification allows an economic interpretation of the magnitude of the underweighting. Specifically, the coefficient on *Bump ratio* × *Ozone ratio* × *Post Bump* is -0.133% (unreported). The median size of a mutual fund portfolio in the pre-bump-up period is $148.08 million. The median dollar value invested by funds in stocks with a non-zero value of *Bump ratio* and *Ozone ratio* is $1.38 million. The standard deviation of *Ozone ratio* across nonattainment plants is 0.316 (unreported). So, a one standard deviation increase in *Bump ratio* and *Ozone ratio* translates into $0.133\% \cdot 0.351 \cdot 0.316 \cdot 148.08/1.38 \approx 1.58\%$ reduction in the dollar value of a stock holding.

unexpected bump-ups as those counties that either: i) reside in the narrow region defined by the optimal bandwidth and are bumped-up subsequently (i.e., unpredictability due to random fluctuations in the DVs); or ii) reside in the region to the left of the left-endpoint of the optimal bandwidth and are bumped-up subsequently (i.e., unobservable non-DV factors). We define anticipated bump-ups to be those counties that reside in the region to the right of the right-endpoint of the optimal bandwidth.[28] We construct the variables *Unexp. bump ratio* and *Antic. bump ratio* to be equal to the number of polluting plants located in unexpected and anticipated bump-up counties for a given firm divided by the total number of nonattainment polluting plants owned by the firm, respectively.

In Panel B of Table 5, we present the estimation results by replacing *Bump ratio* and its corresponding interaction terms in Equation (3) with *Unexp. bump ratio* and *Antic. bump ratio.* Across all columns, only the coefficients on the unexpected component are negative and statistically significant, while those on the anticipated component are much smaller in magnitude and statistically insignificant. Thus, funds only underweight heavy ozone-polluting stocks operating in unexpected bump-up counties and reallocate holdings toward firms operating non-ozone plants in unexpected bump-up counties. Our results are consistent with prior results using nonattainment designations and show that funds primarily hedge against unexpected cash flow shocks.

5.3. Portfolio response to attainment redesignations

Redesignations to attainment represent an easing of regulation, which reduces the compliance costs of heavy ozone-polluting firms. For example, Becker (2005) finds that regulatory costs are significantly less costly to firms operating ozone-polluting plants in attainment counties when compared to those in nonattainment counties. Given a decrease in regulatory stringency, heavy ozone-polluting firms operating in counties facing attainment redesignations experience a positive shock to their cash flows (Ramelli et al., 2021). Thus, under the rational hypothesis, we expect funds to adjust their portfolio holdings in the opposite direction compared to nonattainment designations by overweighting heavy ozone-polluting stocks exposed to attainment redesignations.

To examine changes in portfolio weights during attainment redesignations, we employ a similar empirical setup to that of previous sections, whereby we focus on a five-quarter window

[28] Out of a total of 262 bump-up event-quarters, 201 are classified as unexpected bump-ups, while 61 are considered anticipated.

centered on the attainment redesignation quarter and estimate the following specification:

$$\Delta w_{m,s} = \beta_0 + \beta_1 \textit{Redesig ratio}_{s,t} + \beta_2 \textit{Ozone ratio}_{s,t-1} + \beta_3 \textit{Redesig ratio}_{s,t} \times \textit{Ozone ratio}_{s,t-1} + X_{s,t-1} + X_{m,t-1} + \mu_m + \tau_s + \rho_t + \varepsilon_{m,s,t} \quad (4)$$

for fund m, stock s, and quarter t. The dependent variable is the change in the average weights (in percentage points) of a given stock in a given mutual fund's portfolio during the post-attainment redesignation quarters relative to the pre-attainment redesignation quarters. Since redesignations are conditional on nonattainment status, *Ozone ratio* is defined as the ozone air emissions for a given plant as a proportion of the plant's overall air emissions, averaged across all *nonattainment* plants owned by a given firm. $X_{s,t-1}$ and $X_{m,t-1}$ are vectors of lagged firm-level and fund-level control variables. μ_m, τ_s, and ρ_t are fund, stock, and year-quarter fixed effects, respectively. The coefficient of interest is β_3, which measures the extent to which mutual funds overweight heavy ozone-polluting firms exposed to attainment redesignations.

We present the estimation results of Equation (4) in Panel A of Table 6. Consistent with our predictions, the coefficients on *Redesig ratio* × *Ozone ratio* are positive and statistically significant, indicating that funds overweight heavy ozone-polluting stocks exposed to attainment redesignations. The economic magnitude of the overweighting is also sizable. Specifically, for the median fund in our sample, given a one standard deviation increase *Redesig ratio* and *Ozone ratio*, funds respond to attainment redesignations with a 1.76% increase in the dollar value of such stocks.[29] We also observe a similar reallocation of holdings in response to attainment redesignations. Specifically, funds reallocate holdings *away from* stocks that are exposed to attainment redesignations but do not operate any ozone emitting plants (negative and statistically significant coefficient on *Redesig ratio*), and those that operate ozone emitting plants but are not exposed to attainment redesignations (negative and statistically significant coefficient on *Ozone ratio*). Figure 5 examines the dynamics of portfolio weights surrounding attainment redesignations. We focus on four quarters prior to four quarters after an attainment redesignation. The plot shows no evidence of pre-trends. We find an increase in portfolio

[29] Reverting Equation (4) to a triple difference-in-differences specification allows an economic interpretation of the magnitude of the overweighting. Specifically, the coefficient on *Redesig ratio* × *Ozone ratio* × *Post Redesig* is 0.125% (unreported). The median size of a mutual fund portfolio in the pre-redesignation period is \$166.96 million. The median dollar value invested by funds in stocks with a non-zero value of *Redesig ratio* and *Ozone ratio* is \$1.26 million. The standard deviation of *Ozone ratio* across nonattainment plants is 0.314 (unreported). So, a one standard deviation increase in *Redesig ratio* and *Ozone ratio* translates into $0.125\% \cdot 0.34 \cdot 0.31 \cdot 166.96/1.26 \approx 1.76\%$ increase in the dollar value of a stock holding.

weights in the event quarter, which continues until the fourth quarter post event.

We decompose portfolios' response to attainment redesignations into an unexpected and anticipated component in a similar fashion to the procedure outlined in Section 4.2.2. The only difference is that instead of using RDD to estimate an optimal bandwidth to determine predictability, we use EPA's issuance of a "clean data determination". In nonattainment counties where the DVs have improved to be considerably below the NAAQS threshold, the EPA will issue a clean data determination for these counties, indicating that the air quality has met the required standard. Thus, attentive fund managers who observe which counties receive a clean data determination may be able to predict attainment redesignations, since it signals that the DVs are far enough below the threshold to warrant an attainment redesignation. Similarly, counties that do not receive clean data determinations are those where their DVs are either fluctuating too close around the NAAQS threshold to make a definitive determination or too far above the threshold to make a determination at all. We define unexpected attainment redesignations as those counties that do not receive a clean data determination, but end up redesignated to attainment on the event date. Similarly, anticipated attainment redesignations are those counties that receive a clean data determination and do actually end up redesignated to attainment.[30] We replace *Redesig ratio* and its corresponding interaction terms in Equation (4) with *Unexp. redesig ratio* and *Antic. redesig ratio*, defined to be equal to the number of polluting plants located in unexpected and anticipated attainment redesignation counties for a given firm divided by the total number of nonattainment plants owned by the firm, respectively.

Panel B of Table 6 reports the estimation results. The coefficients on *Unexp. redesig ratio* × *Ozone ratio* are positive and statistically significant, while those on *Antic. redesig ratio* × *Ozone ratio* are considerably smaller in magnitude and statistically insignificant. This result indicates that funds only adjust portfolio holdings in response to the unexpected component of attainment redesignations, consistent with the interpretation that there is little uncertainty on how anticipated attainment redesignations will impact on firms' cash flows. Specifically, anticipated attainment redesignations are those where funds correctly predicted a cease in nonattainment regulations. For firms operating polluting plants in these counties, the real impact of the ease in regulatory costs has already been incorporated into their stock price valuations, implying that portfolio weights would have already adjusted in response to this information before the actual attainment redesignation date.

[30] Out of a total of 472 attainment redesignation event-quarters, 383 are classified as unexpected, while 89 are considered anticipated.

Finally, we explore possible heterogeneity in funds' adjustments of portfolio weights in response to attainment redesignations by conducting the same analysis as in Section 5.1.4. Since attainment redesignations represent a reversal in regulatory stringency, the same firm and fund characteristics that were associated with more *underweighting* in response to nonattainment designations should now lead to more *overweighting.* Figure 7 presents the coefficient estimates and 95% confidence intervals on the triple interaction terms *Unexp. redesig ratio* × *Ozone ratio* × *Z* (in black) and *Antic. redesig ratio* × *Ozone ratio* × *Z* (in blue). In line with the predictions of the rational hypothesis, the point estimates of the unexpected components in Figure 7 have the exact opposite sign to those in Figure 6, while the anticipated components are all statistically insignificant.

Given the strikingly opposite portfolio responses to nonattainment designations and attainment redesignations, one may wonder why funds do not endogenize the portfolio responses to regulatory compliance by choosing an optimal level of holdings from the onset of nonattainment designations rather than rebalancing after attainment redesignations. A plausible explanation is that firms usually operate multiple plants across many counties and each nonattainment county has different plant-specific regulations. For example, in some nonattainment counties, plants are subject to LAER, while plants in other counties may be subject to RACT. Furthermore, depending on the classification of the nonattainment designation, different counties are given different amounts of time to reach attainment. Some counties are allowed only a couple of years, while others are allocated up to 20 years to attain the NAAQS threshold. Thus, given the uncertainty surrounding the impact of attainment redesignations on a firm across all of its polluting plants, it is hard for funds to endogenize the portfolio adjustments of attainment redesignations from the onset.

6. Firm and fund performance in the post-nonattainment period

Our results so far indicate that funds underweight heavy ozone-polluting stocks that are most exposed to nonattainment designations and subsequent bump-up classifications, and overweight them during attainment redesignations. If the underweighting of these stocks is driven by hedging adjustments in response to expected changes in firm fundamentals due to negative cash flow shocks stemming from the costs of nonattainment regulation, then in the post-nonattainment period, we should observe: i) a drop in the performance of heavy ozone-polluting stocks exposed to nonattainment designations; and ii) an improvement in the portfolio performance of funds that engaged in the most underweighting of heavy ozone-polluting stocks exposed to nonattainment designations. We first examine the post-nonattainment operating performance of heavy ozone-polluting stocks exposed to nonattainment designations and then study their abnormal stock returns. Finally, we examine funds' portfolio performance, conditional on the underweighting of such stocks.

6.1. *Impact on firms' operating performance*

We estimate the following triple difference-in-differences specification to evaluate whether heavy ozone-polluting firms exposed to nonattainment regulation adversely impacts on their profitability relative to less-affected stocks:

$$\begin{aligned} Perf_{s,t} &= \beta_0 + \beta_1 NA\ ratio_{s,t} + \beta_2 Ozone\ ratio_{s,t-1} + \beta_3 Post\ NA_t + \beta_4 NA\ ratio_{s,t} \\ &\times Ozone\ ratio_{s,t-1} + \beta_5 NA\ ratio_{s,t} \times Post\ NA_t + \beta_6 Ozone\ ratio_{s,t-1} \times Post\ NA_t \\ &+ \beta_7 NA\ ratio_{s,t} \times Ozone\ ratio_{s,t-1} \times Post\ NA_t + X_{s,t-1} + \text{F.E.} + \varepsilon_{s,t} \end{aligned} \tag{5}$$

for stock s and quarter t. We focus on two quarters before to two quarters after the nonattainment designation and *Post NA* is a dummy variable equal to one for the nonattainment designation quarter and the two following quarters, and zero otherwise. $X_{s,t-1}$ is a vector of lagged firm-level control variables. We include stock and year-quarter fixed effects, as well as industry fixed effects based on Fama and French's (1997) 48 industry classifications. The coefficient of interest is β_7, which measures the post-nonattainment difference in operating performance of heavy ozone-polluting firms exposed to nonattainment designations, as compared to less-affected firms.

We present the results in Table 7. The dependent variable *Perf* is *ROA* in columns (1) and (2), *ROS* (return on sales) in columns (3) and (4), and *Sales growth* in columns (5) and (6). We also use quarter $t-1$ values of the dependent variable as additional control variables. In columns (1), (3), and (5), the coefficients on *NA ratio* × *Ozone ratio* × *Post NA* are all negative and statistically significant, indicating that heavy ozone-polluting firms exposed to nonattainment designations experience worse profitability in the post-nonattainment period, when compared to less-affected firms. For example, a one standard deviation increase in *NA ratio* and *Ozone ratio* lowers ROA by 0.18 percentage points, corresponding to a decrease of 6.41% relative to the sample mean. In contrast, firms that are exposed to nonattainment designations, but do not operate any ozone plants in such counties, do not experience any decrease in operating performance (coefficients on *NA ratio* × *Post NA* are all positive and statistically significant). This result is consistent with the fact that such firms do not experience any negative shocks to their cash flows since they are unaffected by nonattainment designations.

In columns (2), (4), and (6) of Table 7, we augment Equation (5) by replacing *NA ratio* and its interactions with *Unexp. NA ratio* and *Antic. NA ratio*. Only the coefficients on *Unexp. NA ratio* × *Ozone ratio* × *Post NA* are negative and statistically, while those on the anticipated component are smaller in magnitude and not statistically significant. This result shows that unexpected nonattainment designations are the primary drivers of the negative cash flow shocks to the affected firms, which is consistent with our main findings that funds only hedge against the unexpected component of nonattainment regulatory risk.

6.2. Impact on stock returns

We now examine the subsequent abnormal return performance of heavy ozone-polluting stocks exposed to nonattainment regulations. If the underweighting of these stocks is consistent with the rational hypothesis, then we would expect the most underweighted firms to underperform during the post-nonattainment period. However, if the underweighting is due to salience bias, then we should observe significant return reversals. To test this implication, we compare the stock return performance of the most underweighted heavy ozone-polluting stocks that are highly regulated under nonattainment regulations with those that are overweighted.

Specifically, in each nonattainment designation quarter, we first identify top ozone emitting firms as those with an *Ozone ratio* value above the median. Independently, in each nonattainment designation quarter, we identify highly regulated (least regulated) firms as those with a *NA ratio* value above (below) the median. Then, we sort top ozone emitting firms that are highly regulated into tercile portfolios based on the average change in weights across all funds that hold the stock during the two quarters after the nonattainment designation relative to the two quarters before.

We compute equal-weighted DGTW-adjusted CARs (Daniel, Grinblatt, Titman, & Wermers, 1997) for each portfolio for one year before the event quarter (Year−1), one year after the event quarter (Year+1), two years after the event quarter (Year+2), and three years after the event quarter (Year+3). Table 8 shows the results. Panel A presents DGTW-adjusted returns for highly regulated firms, and Panel B reports results for the least regulated firms. Panel C reports the difference in returns between panels A and B. Tercile portfolio 1 is the most underweighted portfolio, whereas tercile portfolio 3 is the most overweighted portfolio. Portfolio $1-3$ represents a zero-investment long-short portfolio that is long tercile 1 and short tercile 3. Standard errors are computed based on Newey-West correction with a lag length of 3.

Panel A shows that the Year−1 CAR between the underweighted and overweighted portfolios are similar. The difference is only 1.2% and is statistically insignificant. It is the post-nonattainment CARs that we are most interested in. In the three years following nonattainment designations, we do not find any evidence of return reversals suggested by the salience hypothesis. Instead, we find that the underweighted portfolio consistently underperforms the overweighted portfolio. The CAR for the $1-3$ portfolio becomes more negative as the horizon increases and the difference is statistically significant. The underperformance is also economically meaningful. For example, for the two year holding horizon, the CAR of -12.5% for the $1-3$ portfolio translates into a loss of approximately $220 million.[31]

Panel B repeats our analysis for the least regulated firms. There is no significant performance difference between the underweighted and overweighted portfolios prior to nonattainment designations. However, in contrast to Panel A, we do not find any evidence of underperformance for the underweighted portfolio in the post-nonattainment years, as the CARs on the $1-3$ portfolio are all close to zero and statistically insignificant. Panel C shows the difference in returns. We find a greater underperformance associated with the $1-3$ portfolio consisting of highly regulated firms during the post-nonattainment years. The incremental underperformance for the $1-3$ portfolio consisting of highly regulated firms over least regulated firms are 7.8% for Year+1, 12.5% for Year+2, and 12.0% for Year+3, with each difference-in-differences estimate being statistically significant. In summary, the findings in this section show that the most underweighted heavy ozone-polluting stocks that are highly regulated under nonattainment regulations exhibit worse abnormal return performance in the post-nonattainment years, consistent with the predictions of the rational hypothesis.

6.3. Impact on funds' portfolio performance

Lastly, we examine whether the underweighting of heavy ozone-polluting stocks exposed to nonattainment designations translates into better investment performance for fund portfolios in the post-nonattainment period. Specifically, funds that hedge against nonattainment regulatory risk by underweighting the most negatively impacted stocks should experience an increase in the value of their rebalanced portfolio when the negative cash flows shocks due to higher regulatory costs materialize in the post-nonattainment period.

Similar to the previous section, in each nonattainment designation quarter, we first identify top ozone emitting firms as those with an *Ozone ratio* value above the median. Independently,

[31] The median market capitalization of the sample of highly regulated top ozone emitting firms belonging to tercile portfolio 1 (portfolio 3) is approximately $1.8 ($1.75) billion. Thus, the median loss for the $1-3$ portfolio over the two years after the nonattainment designation is $0.4\% \times \$1.8$ billion + $12.1\% \times \$1.75$ billion $\approx \$220$ million.

in each nonattainment designation quarter, we identify highly regulated firms as those with a *NA ratio* value above the median. We then sort funds into terciles based on the average change in weights across all stocks in their portfolio that are classified as top ozone emitting and highly regulated firms during the two quarters after the nonattainment designation relative to the two quarters before. We define *Low* Δw to be a dummy variable equal to one if a fund is in the lowest tercile, and zero otherwise. Thus, *Low* Δw represents the sample of funds that hedge against nonattainment regulatory risk the most.

Following Gibson et al. (2021), we focus on six quarters before to eight quarters after the nonattainment designation and regress eight quarter forward rolling portfolio-level performance measures on a series of time dummies and their interactions with *Low* Δw. The time dummies include $Post[0,2]$, which is a dummy variable equal to one for quarters t, $t+1$, and $t+2$, and zero otherwise. $Post[3,4]$, $Post[5,6]$, $Post[7,8]$, $Pre[-4,-3]$, and $Pre[-6,-5]$ are defined analogously. The omitted category is $Pre[-2,-1]$. We include fund control variables and also value-weighted average characteristics of the portfolio's stock holdings. We use fund and year-quarter fixed effects.

Table 9 presents the results. The dependent variable in column (1) is the mean portfolio return calculated as the eight quarter forward (i.e., between quarter t and $t+7$) rolling average of the quarterly holding returns. Column (2) uses the total portfolio risk calculated as the eight quarter forward rolling standard deviation of the quarterly holding returns. Column (3) is the eight quarter forward rolling Sharpe ratio. Column (4) is the alpha from a Fama and French (1993) three factor model estimated using eight quarter forward rolling windows. We first verify the absence of pre-trends since the coefficients on *Low* $\Delta w \times Pre[-6,-5]$ and *Low* $\Delta w \times Pre[-4,-3]$ across all four columns are statistically indistinguishable from zero. Thus, there does not appear to be any differential trend in portfolio performance between funds that conduct the most underweighting and those that underweight less in the pre-nonattainment period.

However, focusing on the quarters after the nonattainment designation, we see that funds that engage in the most underweighting of the heavily regulated top ozone-polluting firms experience superior portfolio performance. For instance, columns (3) and (4) indicate that these funds have higher portfolio-level Sharpe ratios and alphas. Column (2) indicates that the superior Sharpe ratio these funds experience are a result of a decrease in total portfolio risk in the first two quarters after the nonattainment designation, while column (1) shows that the superior performance from the third quarter post event onwards is a result of higher portfolio returns. Overall, the evidence in this section shows that fund portfolios that hedge against nonattainment regulatory risks by underweighting those heavily regulated top ozone-polluting firms perform better in the post-nonattainment period, in line with the predictions of the rational hypothesis.

7. Underweighting and regulatory compliance costs

The rational hypothesis asserts that the negative shock to the cash flows of heavy ozone-polluting firms exposed to nonattainment designations is due to an increase in regulatory compliance costs. Thus, if the underweighted top ozone-polluting firms are those that funds expect to be most negatively impacted by nonattainment designations, then the compliance costs of such firms should increase with their exposure to nonattainment designations in the post-nonattainment period. Ideally, we would want to use a firm's pollution abatement costs as a measure of their regulatory compliance costs. However, there is no available data directly on plant-level pollution abatement costs. Thus, following Xu and Kim (2022), we proxy for the potential compliance costs associated with nonattainment designations by examining facilities' observable pollution abatement efforts through source reduction activities and regulatory enforcement. The intuition is that facilities with more engagements in source reduction activities and regulatory enforcements presumably have higher compliance costs.

For facilities' pollution abatement efforts, we use data from EPA's Pollution Prevention (P2) database. Plants reporting to the TRI database are required to document the amount of source reduction activities at the chemical level that limit the amount of hazardous substances being released. Ozone emissions can either undergo treatment, recycling, or recovery (collectively known as the total amount of source reduction) before being released into the environment. Plants are also required to report the type of abatement activities that they engage in, the most common being "good operating practices", which comprises actions such as improved maintenance scheduling, record keeping, or procedures. The second most common abatement activity is "process modifications", which includes actions such as modifying equipment, layout, or piping.

We examine four types of regulatory enforcements including high priority violations (HPV), Title V inspections, stack tests, and compliance evaluations. HPVs are serious plant violations that subject a facility to the threat of high fines, additional reporting, and intense regulatory oversight.[32] The other three enforcement activities are essentially evaluation tests conducted for

[32] HPVs cover a broad range of issues including excess emissions, failure to install plant modifications, and violating an operating parameter, among others.

the purposes of determining and demonstrating a facility's compliance with CAA regulations. Failing these tests has potential negative consequences in that the facility could be labeled as a high priority violator. We obtain the data on these regulatory enforcements from EPA's ICIS-Air database.

In each nonattainment designation quarter, we first identify top ozone emitting firms as those with an *Ozone ratio* value above the median. Then, focusing only on the top ozone emitting firms, we sort them into terciles based on the average change in weights across all funds that hold the stock during the two quarters after the nonattainment designation relative to the two quarters before. We define *Underweight* to be a dummy variable equal to one if a firm is in the lowest tercile, and zero otherwise. Thus, *Underweight* represents the sample of top ozone emitting firms that are underweighted the most by funds.

We focus on five years before to five years after the nonattainment designation because the real regulatory impact of nonattainment designations could take up to several years to be felt by nonattainment plants (Gibson, 2019). Formally, we estimate the following regression specification:

$$\begin{aligned} &reg\ cost_{s,t} = \beta_0 + \beta_1 NA\ ratio_{s,t} + \beta_2 Underweight_{s,t} + \beta_3 Post\ NA_t + \beta_4 NA\ ratio_{s,t} \\ &\times Underweight_{s,t} + \beta_5 NA\ ratio_{s,t} \times Post\ NA_t + \beta_6 Underweight_{s,t} \times Post\ NA_t \\ &+ \beta_7 NA\ ratio_{s,t} \times Underweight_{s,t} \times Post\ NA_t + \text{Controls} + \text{F.E.} + \varepsilon_{s,t} \end{aligned} \tag{6}$$

for stock s and year t. *Post NA* is a dummy variable equal to one for the nonattainment designation year and the five following years, and zero otherwise. We include firm-level control variables, as well as stock, year, and industry fixed effects. The dependent variables, *reg cost*, measure a firm's regulatory compliance costs proxied by observable pollution abatement efforts and regulatory enforcement across its nonattainment plants and are defined when we present the results. The coefficient of interest is β_7, which measures the differential regulatory costs for the most underweighted top ozone emitting firms that are very exposed to nonattainment designations in the post-nonattainment years, when compared to those that are less exposed.

Table 10 presents the results. The dependent variables in columns (1) and (2) are a dummy variable equal to one if a given firm undertakes ozone-related source reduction activities at plants located in nonattainment counties and the natural logarithm of one plus the amount of ozone air emissions that undergo source reduction of a given firm across all of its plants located in nonattainment counties, respectively. Both coefficients on $NA\ ratio \times Underweight \times Post\ NA$ are positive and statistically significant, indicating that underweighted top ozone-polluting firms that are more exposed to nonattainment designations invest more in pollution abatement across their nonattainment plants in the post-nonattainment years.

In Columns (3), (4), (5), and (7), the dependent variables are the natural logarithm of one plus the number of HPVs, Title V inspections, stack tests, and compliance evaluations of a given firm across all of its plants located in nonattainment counties, respectively. In column (4), we use a dummy variable equal to one if a given firm operates a plant located in a nonattainment county that failed a stack test, and zero otherwise. The coefficients on *NA ratio* × *Underweight* × *Post NA* are all positive and statistically significant, indicating that underweighted top ozone-polluting firms with more exposure to nonattainment designations face more regulatory enforcement in the post-nonattainment years. Overall, the evidence is consistent with the rational hypothesis in that funds hedge against nonattainment regulatory risks by underweighting heavy ozone-polluting firms that are most exposed to nonattainment designations, since these firms bear the majority of regulatory compliance costs.

8. Robustness

We perform a number of robustness checks and falsification tests. For brevity, we report a concise summary of these tests, while the detailed descriptions and corresponding tables can be found in Section IB of the Internet Appendix. Our main results on portfolio responses to nonattainment designations are robust to: i) various windows around the nonattainment designations; ii) alternative outcome variables measuring portfolio response to mitigate concerns related to temporary drops in the stock price of polluting firms; iii) controlling for the inherent heterogeneity of each chemical by using toxicity-weighted ozone air emissions; iv) using only core ozone chemicals to mitigate the concern of reporting errors in the TRI data; v) falsification tests using offsite ozone emissions; vi) alternative measures of exposure to nonattainment designations to reflect the relative importance of a firm's different polluting plants; vii) controlling for firms self-selecting into nonattainment counties; viii) controlling for a fund's sustainability footprint (Azar, Duro, Kadach, & Ormazabal, 2021; Choi, Gao, Jiang, & Zhang, 2021; Gibson et al., 2021); and ix) controlling for demand for ESG investment fund flows (Ceccarelli et al., 2021; Hartzmark & Sussman, 2019; Riedl & Smeets, 2017).

We also conduct several robustness checks and falsification tests on firms' performance in the post-nonattainment period. Specifically, our results remain unchanged when we use buy-and-hold stock returns (Barber & Lyon, 1997) rather than CARs. In a falsification test, we replicate the analysis in Section 7, but focus on the sample of *low* ozone emitting firms. Consistent with the fact that low ozone emitting firms are less impacted by the NAAQS, regardless of their exposure to nonattainment designations, we find that the source reduction activities and regulatory enforcement of underweighted low ozone-polluting firms do not depend on their exposure to nonattainment designations. Lastly, we examine the possibility that the underweighting of top ozone-polluting firms causes a change in their emission behavior, which in turn impacts on their regulatory status (Kim, Wan, Wang, & Yang, 2019). However, we show that the underweighting of top ozone-polluting firms do not significantly influence their ozone emissions or penalties in the post-nonattainment period.

9. Conclusion

Environmental risks have received more focused attention from financial market participants over the past few years. In this study, we examine the response of mutual fund portfolios to environmental *regulatory* risks.

Using exogenous variation in local regulatory stringency driven by nonattainment designations, we find that funds underweight (overweight) those polluting stocks whose cash flows covary negatively (positively) with the regulatory shock. We validate our results using two related types of environmental regulatory events including bump-up classifications and attainment redesignations. Funds continue to underweight heavy ozone-polluting stocks exposed to bump-ups, while they overweight such stocks during attainment redesignations. Our results are consistent with hedging adjustments in response to expected changes in firm fundamentals due to negative cash flow shocks stemming from the costs of nonattainment regulation.

Examining the performance in the post-nonattainment period, we find that heavy ozone-polluting firms exposed to nonattainment designations have worse operating performance and the most underweighted of such firms exhibit lower CARs relative to the most overweighted. The underweighting translates into superior investment portfolio performance. Finally, the heavy ozone-polluting stocks exposed to nonattainment designations that are underweighted also correspond to those that experience an increase in regulatory compliance costs in the post-nonattainment period.

The findings in this study demonstrate that environmental regulations have important implications for the allocation of capital of polluting firms in financial markets. Although shifting capital away from the biggest polluters exposed to stringent environmental regulations may increase the value of funds' portfolios, it may be detrimental to overall welfare as these are the firms that require funding for the transition to a greener economy. Thus, an exciting avenue for future research would be to evaluate the welfare and policy consequences of environmental regulation-driven capital allocations.

References

Akey, P., & Appel, I. (2021). The limits of limited liability: Evidence from industrial pollution. *Journal of Finance*, *76*(1), 5–55.

Alekseev, G., Giglio, S., Maingi, Q., Selgrad, J., & Stroebel, J. (2022). A quantity-based approach to constructing climate risk hedge portfolios. Working Paper, NYU.

Alok, S., Kumar, N., & Wermers, R. (2020). Do fund managers misestimate climatic disaster risk. *Review of Financial Studies*, *33*(3), 1146–1183.

Amihud, Y., & Goyenko, R. (2013). Mutual fund's R^2 as predictor of performance. *Review of Financial Studies*, *26*(3), 667–694.

Auffhammer, M., Bento, A. M., & Lowe, S. E. (2009). Measuring the effects of the Clean Air Act Amendments on ambient PM_{10} concentrations: The critical importance of a spatially disaggregated analysis. *Journal of Environmental Economics and Management*, *58*(1), 15–26.

Azar, J., Duro, M., Kadach, I., & Ormazabal, G. (2021). The Big Three and corporate carbon emissions around the world. *Journal of Financial Economics*, *142*(2), 674–696.

Baker, S. D., Hollifield, B., & Osambela, E. (2022). Asset prices and portfolios with externalities. *Review of Finance*, *Forthcoming*.

Barber, B. M., & Lyon, J. D. (1997). Detecting long-run abnormal stock returns: The empirical power and specification of test statistics. *Journal of Financial Economics*, *43*(3), 341–372.

Becker, R. A. (2005). Air pollution abatement costs under the Clean Air Act: Evidence from the PACE survey. *Journal of Environmental Economics and Management*, *50*(1), 144–169.

Becker, R. A., & Henderson, V. (2000). Effects of air quality regulations on polluting industries. *Journal of Political Economy*, *108*(2), 379–421.

Becker, R. A., & Henderson, V. (2001). Costs of air quality regulation. *In: Behavioral and distributional effects of environmental policy, Carraro, C. and Metcalf, G. E., eds. (Chicago: University of Chicago Press)*, 159–186.

Bento, A. M., Freedman, M., & Lang, C. (2015). Who benefits from environmental regulation? Evidence from the Clean Air Act Amendments. *Review of Economics and Statistics*, *97*(3), 610–622.

Bertrand, M., Duflo, E., & Mullainathan, S. (2004). How much should we trust differences-in-differences estimates? *Quarterly Journal of Economics*, *119*(1), 249–275.

Bharath, S. T., & Cho, D. (2022). Do natural disaster experiences limit stock market participation? *Journal of Financial and Quantitative Analysis*, *Forthcoming*.

Bishop, K. C., Ketcham, J. D., & Kuminoff, N. V. (2022). Hazed and confused: The effect of air pollution on dementia. NBER Working Paper No. 24970.

Bolton, P., & Kacperczyk, M. (2020). Carbon premium around the world. CEPR Discussion Papers 14567.

Bolton, P., & Kacperczyk, M. (2021). Do investors care about carbon risk? *Journal of*

Financial Economics, *142*(2), 517–549.
Borgers, A., Derwall, J., Koedijk, K., & ter Horst, J. (2015). Do social factors influence investment behavior and performance? Evidence from mutual fund holdings. *Journal of Banking & Finance*, *60*, 112–126.
Borochin, P., Celik, M. A., Tian, X., & Whited, T. M. (2022). Identifying the heterogeneous impact of highly anticipated events: Evidence from the Tax Cuts and Jobs Act. Working Paper.
Bui, L. T. M., & Mayer, C. J. (2003). Regulation and capitalization of environmental amenities: Evidence from the Toxic Release Inventory in Massachusetts. *Review of Economics and Statistics*, *85*(3), 693–708.
Calonico, S., Cattaneo, M. D., & Titiunik, R. (2014). Robust nonparametric confidence intervals for regression-discontinuity designs. *Econometrica*, *82*(6), 2295–2326.
Cao, J., Li, Y., Zhan, X., Zhang, W., & Zhou, L. (2022). Carbon emissions, mutual fund trading, and the liquidity of corporate bonds. CUHK Working Paper.
Cao, J., Titman, S., Zhan, X., & Zhang, W. (2021). ESG preference, institutional trading, and stock return patterns. *Journal of Financial and Quantitative Analysis*, *Forthcoming*.
Cattaneo, M. D., Jansson, M., & Ma, X. (2020). Simple local polynomial density estimators. *Journal of the American Statistical Association*, *115*(531), 1449–1455.
Ceccarelli, M., Ramelli, S., & Wagner, A. F. (2021). Low-carbon mutual funds. Swiss Finance Institute Research Paper No. 19-13.
Chava, S. (2014). Environmental externalities and cost of capital. *Management Science*, *60*(9), 2223–2247.
Chay, K. Y., & Greenstone, M. (2003). Air quality, infant mortality, and the Clean Air Act of 1970. NBER Working Paper No. 10053.
Chay, K. Y., & Greenstone, M. (2005). Does air quality matter? Evidence from the housing market. *Journal of Political Economy*, *113*(2), 376–424.
Choi, D., Gao, Z., & Jiang, W. (2020). Attention to global warming. *Review of Financial Studies*, *33*(3), 1112–1145.
Choi, D., Gao, Z., Jiang, W., & Zhang, H. (2021). Global carbon divestment and firms' actions. Working Paper.
Cleveland, W. S., & Graedel, T. E. (1979). Photochemical air pollution in the northeast United States. *Science*, *204*, 1273–1278.
Cleveland, W. S., Kleiner, B., McRae, J. E., & Warner, J. L. (1976). Photochemical air pollution: Transport from the New York City area into Connecticut and Massachusetts. *Science*, *191*, 179–181.
Cremers, K. J. M., & Petajisto, A. (2009). How active is your fund manager? A new measure that predicts performance. *Review of Financial Studies*, *22*(9), 3329–3365.
Curtis, E. M. (2020). Reevaluating the ozone nonattainment standards: Evidence from the 2004 expansion. *Journal of Environmental Economics and Management*, *99*.
Daniel, K., Grinblatt, M., Titman, S., & Wermers, R. (1997). Measuring mutual fund

performance with characteristic-based benchmarks. *Journal of Finance*, *52*(3), 1035–1058.

Delis, M. D., de Greiff, K., Iosifidi, M., & Ongena, S. (2021). Being stranded with fossil fuel reserves? Climate policy risk and the pricing of bank loans. Swiss Finance Institute Research Paper No. 18-10.

De Marchi, S., & Hamilton, J. T. (2006). Assessing the accuracy of self-reported data: An evaluation of the Toxics Release Inventory. *Journal of Risk and Uncertainty*, *32*, 57–76.

Doshi, H., Elkamhi, R., & Simutin, M. (2015). Managerial activeness and mutual fund performance. *Review of Asset Pricing Studies*, *5*(2), 156–184.

Elton, E. J., Gruber, M. J., & Blake, C. R. (2001). A first look at the accuracy of the CRSP mutual fund database and a comparison of the CRSP and Morningstar mutual fund databases. *Journal of Finance*, *56*(6), 2415–2430.

Fama, E. F., & French, K. R. (1993). Common risk factors in the returns on stocks and bonds. *Journal of Financial Economics*, *33*(1), 3–56.

Fama, E. F., & French, K. R. (1997). Industry costs of equity. *Journal of Financial Economics*, *43*(2), 153–193.

Foroughi, P., Marcus, A. J., & Nguyen, V. (2021). Does a mutual fund's exposure to pollution influence its environmental engagements? Working Paper.

Gamper-Rabindran, S. (2006). Did the EPA's voluntary industrial toxics program reduce emissions? A GIS analysis of distributional impacts and by-media analysis of substitution. *Journal of Environmental Economics and Management*, *52*(1), 391–410.

Gantchev, N., Giannetti, M., & Li, R. (2021). Does money talk? Market discipline through selloffs and boycotts. European Corporate Governance Institute Finance Working Paper No. 634/2019.

Gibson, M. (2019). Regulation-induced pollution substitution. *Review of Economics and Statistics*, *101*(5), 827–840.

Gibson, R., Krueger, P., & Mitali, S. F. (2021). The sustainability footprint of institutional investors: ESG driven price pressure and performance. Swiss Finance Institute Research Paper No. 17-05.

Grainger, C. A. (2012). The distributional effects of pollution regulations: Do renters fully pay for cleaner air? *Journal of Public Economics*, *96*(9–10), 840–852.

Greenstone, M. (2002). The impacts of environmental regulations on industrial activity: Evidence from the 1970 and 1977 Clean Air Act Amendments and the census of manufactures. *Journal of Political Economy*, *110*(6), 1175–1219.

Greenstone, M. (2003). Estimating regulation-induced substitution: The effect of the Clean Air Act on water and ground pollution. *American Economic Review: AEA Papers and Proceedings*, *93*(2), 442–448.

Greenstone, M., List, J. A., & Syverson, C. (2012). The effects of environmental regulation on the competitiveness of U.S. manufacturing. NBER Working Paper No. 18392.

Hartzmark, S. M., & Sussman, A. B. (2019). Do investors value sustainability? A natural experiment examining ranking and fund flows. *Journal of Finance*, *74*(6), 2789–2837.

Heckman, J. J. (1979). Sample selection bias as a specification error. *Econometrica*, *47*(1), 153–161.

Henderson, J. V. (1996). Effects of air quality regulation. *American Economic Review*, *86*(4), 789–813.

Hoepner, A. G. F., Oikonomou, I., Sautner, Z., Starks, L., & Zhou, X. Y. (2022). ESG shareholder engagement and downside risk. European Corporate Governance Institute Finance Working Paper No. 671/2020.

Hong, H., & Kostovetsky, L. (2012). Red and blue investing: Values and finance. *Journal of Financial Economics*, *103*(1), 1–19.

Hsu, P. H., Li, K., & Tsou, C. Y. (2022). The pollution premium. *Journal of Finance*, *Forthcoming.*

Huynh, T., Li, F. W., & Xia, Y. (2021). Something in the air: Does air pollution affect fund managers' carbon divestment? Working Paper.

Ilhan, E., Krueger, P., Sautner, Z., & Starks, L. T. (2021). Climate risk disclosure and institutional investors. Swiss Finance Institute Research Paper No. 19-66.

Isen, A., Rossin-Slater, M., & Walker, W. R. (2017). Every breath you take – every dollar you'll make: The long-term consequences of the Clean Air Act of 1970. *Journal of Political Economy*, *125*(3), 848–902.

Jagannathan, R., Ravikumar, A., & Sammon, M. (2022). Environmental, social, and governance criteria: Why investors are paying attention. NBER Working Paper No. 24063.

Jha, A., Karolyi, S. A., & Muller, N. Z. (2020). Polluting public funds: The effect of environmental regulation on municipal bonds. NBER Working Paper No. 28210.

Jouvenot, V., & Krueger, P. (2021). Mandatory corporate carbon disclosure: Evidence from a natural experiment. University of Geneva Working Paper.

Kacperczyk, M., Sialm, C., & Zheng, L. (2005). On the industry concentration of actively managed equity mutual funds. *Journal of Finance*, *60*(4), 1983–2011.

Kahn, M. E., & Mansur, E. T. (2013). Do local energy prices and regulation affect the geographic concentration of employment? *Journal of Public Economics*, *101*, 105–114.

Kang, J. K., & Stulz, R. M. (1997). Why is there a home bias? An analysis of foreign portfolio equity ownership in Japan. *Journal of Financial Economics*, *46*(1), 3–28.

Kim, I., Wan, H., Wang, B., & Yang, T. (2019). Institutional investors and corporate environmental, social, and governance policies: Evidence from toxics release data. *Management Science*, *65*(10), 4451–4949.

Kleimeier, S., & Viehs, M. (2018). Carbon disclosure, emission levels, and the cost of debt. Working Paper, Maastricht University and Oxford University.

Krueger, P., Sautner, Z., & Starks, L. T. (2020). The importance of climate risks for institutional investors. *Review of Financial Studies*, *33*(3), 1067–1111.

Lee, D. S., & Lemieux, T. (2010). Regression discontinuity designs in economics. *Journal of*

Economic Literature, *48*(2), 281–355.

Li, J. J., Massa, M., Zhang, H., & Zhang, J. (2021). Air pollution, behavioral bias, and the disposition effect in China. *Journal of Financial Economics*, *142*(2), 641–673.

List, J. A., McHone, W. W., & Millimet, D. L. (2004). Effects of environmental regulation on foreign and domestic plant births: Is there a home field advantage? *Journal of Urban Economics*, *56*(2), 303–326.

List, J. A., Millimet, D. L., Fredriksson, P. G., & McHone, W. W. (2003). Effects of environmental regulations on manufacturing plant births: Evidence from a propensity score matching estimator. *Review of Economics and Statistics*, *85*(4), 944–952.

McCrary, J. (2008). Manipulation of the running variable in the regression discontinuity design: A density test. *Journal of Econometrics*, *142*(2), 698–714.

Monasterolo, I., & de Angelis, L. (2020). Blind to carbon risk? An analysis of stock market reaction to the Paris Agreement. *Ecological Economics*, *170*, 1–9.

Nofsinger, J. R., Sulaeman, J., & Varma, A. (2019). Institutional investors and corporate social responsibility. *Journal of Corporate Finance*, *58*, 700-725.

Pástor, L., Stambaugh, R. F., & Taylor, L. A. (2021). Sustainable investing in equilibrium. *Journal of Financial Economics*, *142*(2), 550–571.

Pedersen, L. H., Fitzgibbons, S., & Pomorski, L. (2021). Responsible investing: The ESG-efficient frontier. *Journal of Financial Economics*, *142*(2), 572–597.

Petersen, M. A. (2009). Estimating standard errors in finance panel data sets: Comparing approaches. *Review of Financial Studies*, *22*(1), 435–480.

Pool, V. K., Stoffman, N., & Yonker, S. E. (2012). No place like home: Familiarity in mutual fund manager portfolio choice. *Review of Financial Studies*, *25*(8), 2563–2599.

Ramelli, S., Wagner, A. F., Zeckhauser, R. J., & Ziegler, A. (2021). Investor rewards to climate responsibility: Stock-price responses to the opposite shocks of the 2016 and 2020 U.S. elections. *Review of Corporate Finance Studies*, *10*(4), 748–787.

Riedl, A., & Smeets, P. (2017). Why do investors hold socially responsible mutual funds? *Journal of Finance*, *72*(6), 2505–2550.

Roberts, M. R., & Whited, T. M. (2013). Endogeneity in empirical corporate finance. *Handbook of the Economics of Finance*, *2*, 493–572.

Ryan, S. P. (2012). The costs of environmental regulation in a concentrated industry. *Econometrica*, *80*(3), 1019–1061.

Seltzer, L., Starks, L. T., & Zhu, Q. (2021). Climate regulatory risks and corporate bonds. Nanyang Business School Research Paper No. 20-05.

Shapiro, J. S., & Walker, W. R. (2018). Why is pollution from US manufacturing declining? The roles of environmental regulation, productivity, and trade. *American Economic Review*, *108*(12), 3814–3854.

Sheriff, G., Ferris, A. E., & Shadbegian, R. J. (2019). How did air quality standards affect employment at US power plants? The importance of timing, geography, and stringency. *Journal of the Association of Environmental and Resource Economists*, *6*(1), 111–149.

Starks, L., Venkat, P., & Zhu, Q. (2020). Corporate ESG profiles and investor horizons. Working Paper, University of Texas at Austin.

Stroebel, J., & Wurgler, J. (2021). What do you think about climate finance? *Journal of Financial Economics*, *142*(2), 487–498.

US EPA. (1998). 1994 and 1995 Toxic Release Inventory: Data quality report. https://nepis.epa.gov/Exe/ZyPDF.cgi/20009LE0.PDF?Dockey=20009LE0.PDF.

US EPA. (2006). Reasonably available control technology (RACT) questions and answers. https://www.epa.gov/sites/default/files/2016-08/documents/ract_and_nsps_1dec1988.pdf.

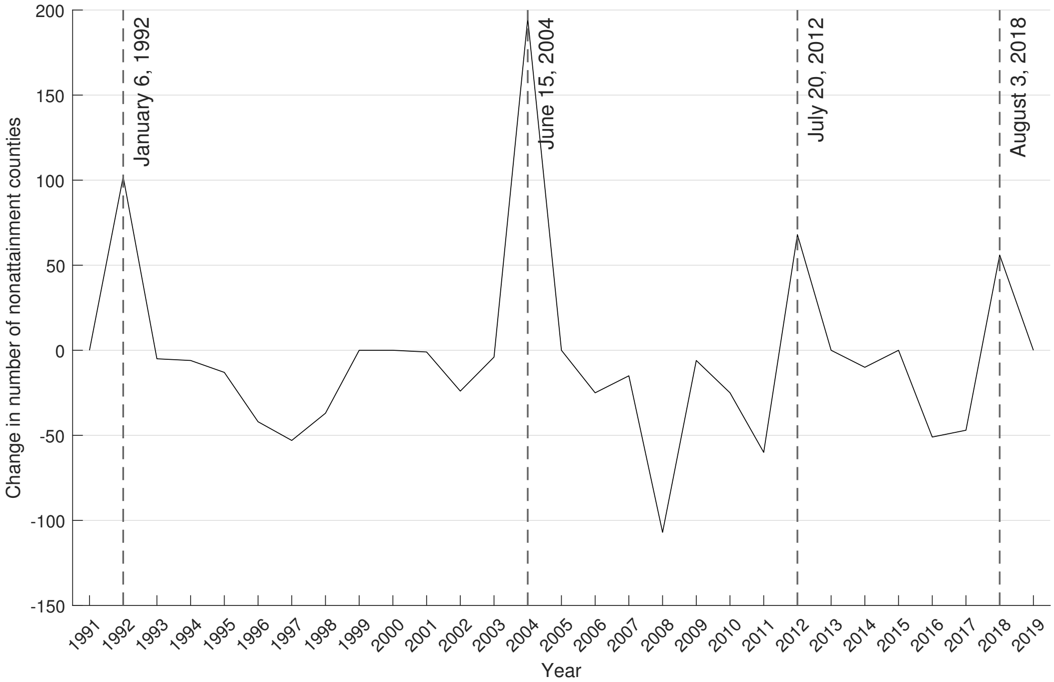
US EPA. (2013). Guidance on infrastructure state implementation plan (SIP) elements under Clean Air Act sections 110(a)(1) and 110(a)(2). https://www.epa.gov/sites/default/files/2015-12/documents/guidance_on_infrastructure_sip_elements_multipollutant_final_sept_2013.pdf.

Walker, W. R. (2011). Environmental regulation and labor reallocation: Evidence from the Clean Air Act. *American Economic Review: AEA Papers and Proceedings*, *101*(3), 442–447.

Walker, W. R. (2013). The transitional costs of sectoral reallocation: Evidence from the Clean Air Act and the workforce. *Quarterly Journal of Economics*, *128*(4), 1787–1835.

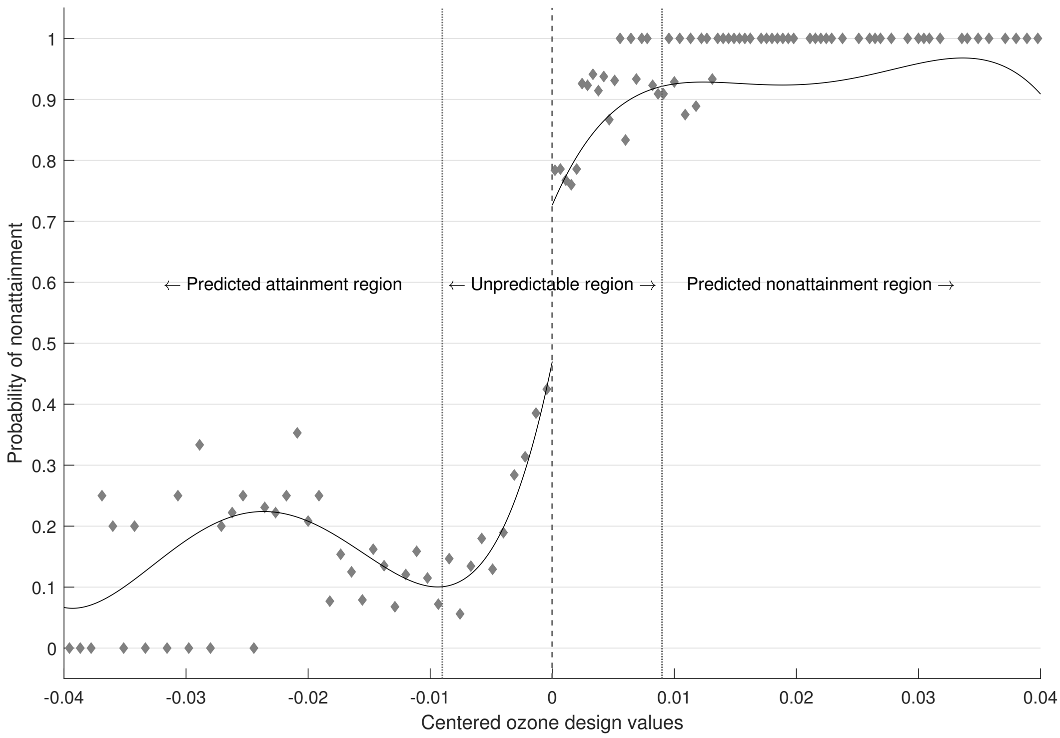
Xu, Q., & Kim, T. (2022). Financial constraints and corporate environmental policies. *Review of Financial Studies*, *35*(2), 576-635.

Figure 1
Policy changes in the NAAQS threshold and change in the number of nonattainment counties.



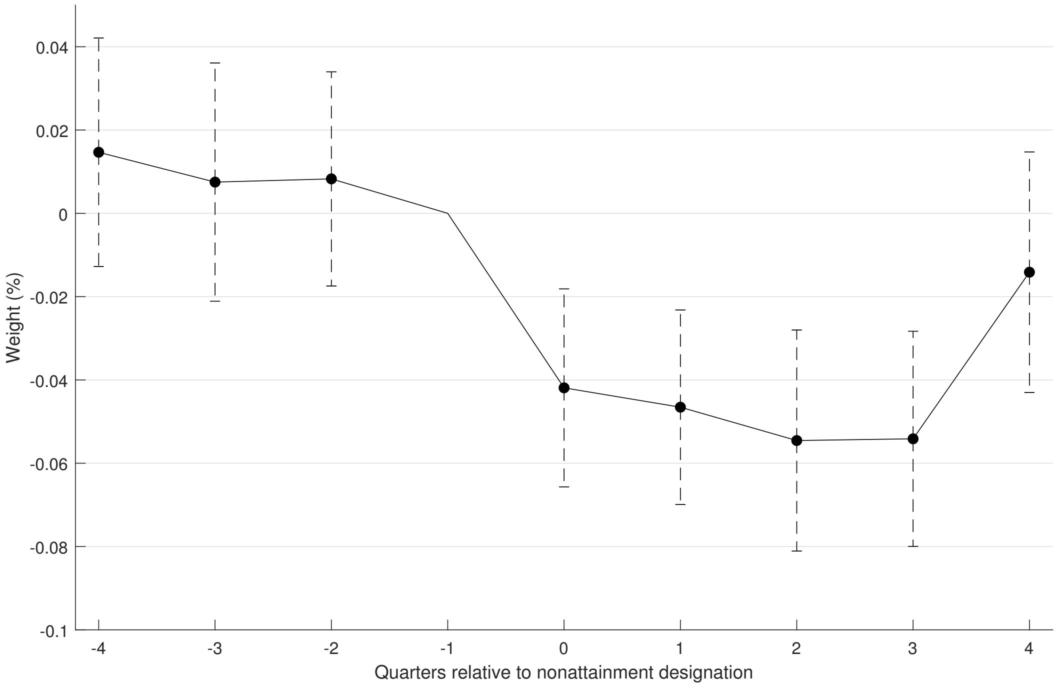
This figure shows the four discrete policy changes in the NAAQS threshold and the yearly change in the number of nonattainment counties during the sample period 1992 to 2019. In chronological order, the revisions to the NAAQS threshold include the 1-Hour Ozone (1979) standard effective on January 6, 1992, 8-Hour Ozone (1997) standard effective on June 15, 2004, 8-Hour Ozone (2008) standard effective on July 20, 2012, and 8-Hour Ozone (2015) standard effective on August 3, 2018. Each of these revisions is represented by a dashed vertical line. For more details, see Table IA.1 of the Internet Appendix. The solid black lines represent the difference in the number of nonattainment counties between the current year and the previous year.

Figure 2
Probability of nonattainment around ozone NAAQS thresholds.



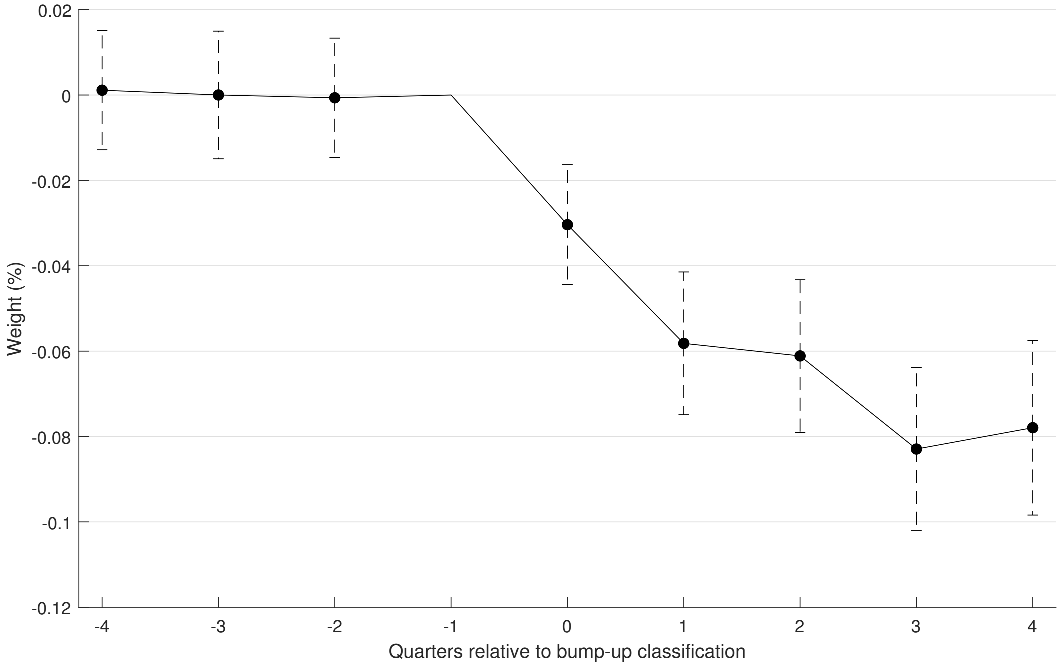
This figure presents the regression discontinuity relating centered DVs to the probability of nonattainment. The regression discontinuity is estimated from the local linear regression specification given in Equation (2) using the mean squared error optimal bandwidth with rectangular kernels following Calonico et al. (2014). We use the sample of nonattainment designations based on revisions in the NAAQS threshold in the estimation. The vertical axis shows the probability of nonattainment. The horizontal axis shows the centered DVs around zero by subtracting the NAAQS threshold from the DVs. The dashed vertical line at zero represents the NAAQS threshold for ozone nonattainment status. Observations on the right (left) of the line indicate that the county is in violation of (compliance with) the NAAQS threshold. Each dot in the figure represents the average of $NA_{c,t+1}$, defined as a dummy variable equal to one if county c is designated nonattainment in year $t+1$, using integrated mean squared error optimal bins following Calonico et al. (2014). The solid lines on either side of the NAAQS threshold is based on two separate regressions of $NA_{c,t+1}$ on local quartic polynomials in centered DVs using the rectangular kernel and mean squared error optimal bandwidth following Calonico et al. (2014). The unpredictable region refers to the narrow region surrounding the NAAQS threshold, which is bounded by the mean squared error optimal bandwidth following Calonico et al. (2014). The predicted nonattainment region refers to the region on the right of the right-endpoint of the optimal bandwidth. The predicted attainment region refers to the region on the left of the left-endpoint of the optimal bandwidth. For more details regarding the estimation of the optimal bandwidth, refer to Table IA.3 of the Internet Appendix.

Figure 3
Dynamics of portfolio response to nonattainment designations.



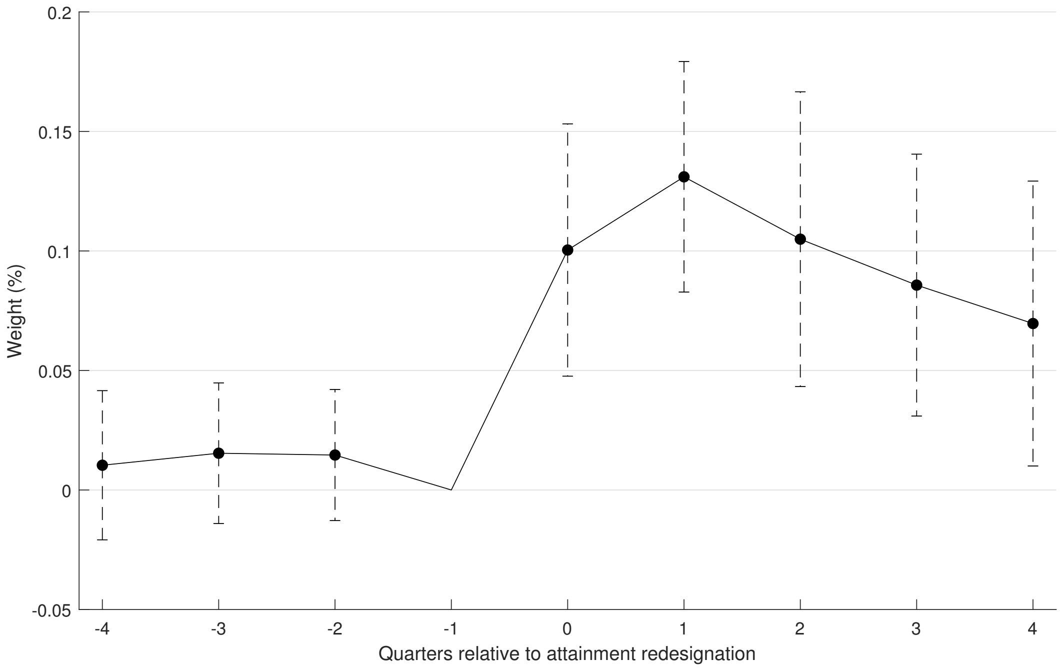
This figure shows the point estimates (solid line) and 95% confidence intervals (dashed lines) of the coefficients for the interaction term, $NA\ ratio_t \times Ozone\ ratio_{t-1} \times Post\ NA(k)$, where k ranges from -4 to $+4$ quarters surrounding the nonattainment designation. The quarter before the nonattainment designation is the omitted category. The dependent variable is the weight (in percentage points) of a given stock in a given mutual fund's portfolio. *NA ratio* equals to the number of polluting plants located in nonattainment counties for a given firm divided by the total number of plants owned by the firm. *Ozone ratio* is the ozone air emissions for a given plant as a proportion of the plant's overall air emissions averaged across all plants owned by a given firm.

Figure 4
Dynamics of portfolio response to bump-up classifications.



This figure shows the point estimates (solid line) and 95% confidence intervals (dashed lines) of the coefficients for the interaction term, *Bump ratio*$_t$ × *Ozone ratio*$_{t-1}$ × *Post Bump(k)*, where k ranges from -4 to $+4$ quarters surrounding the bump-up classification. The quarter before the bump-up classification is the omitted category. The dependent variable is the weight (in percentage points) of a given stock in a given mutual fund's portfolio. *Bump ratio* equals to the number of polluting plants located in nonattainment counties experiencing bump-ups for a given firm divided by the total number of nonattainment plants owned by the firm. *Ozone ratio* is the ozone air emissions for a given plant as a proportion of the plant's overall air emissions averaged across all nonattainment plants owned by a given firm.

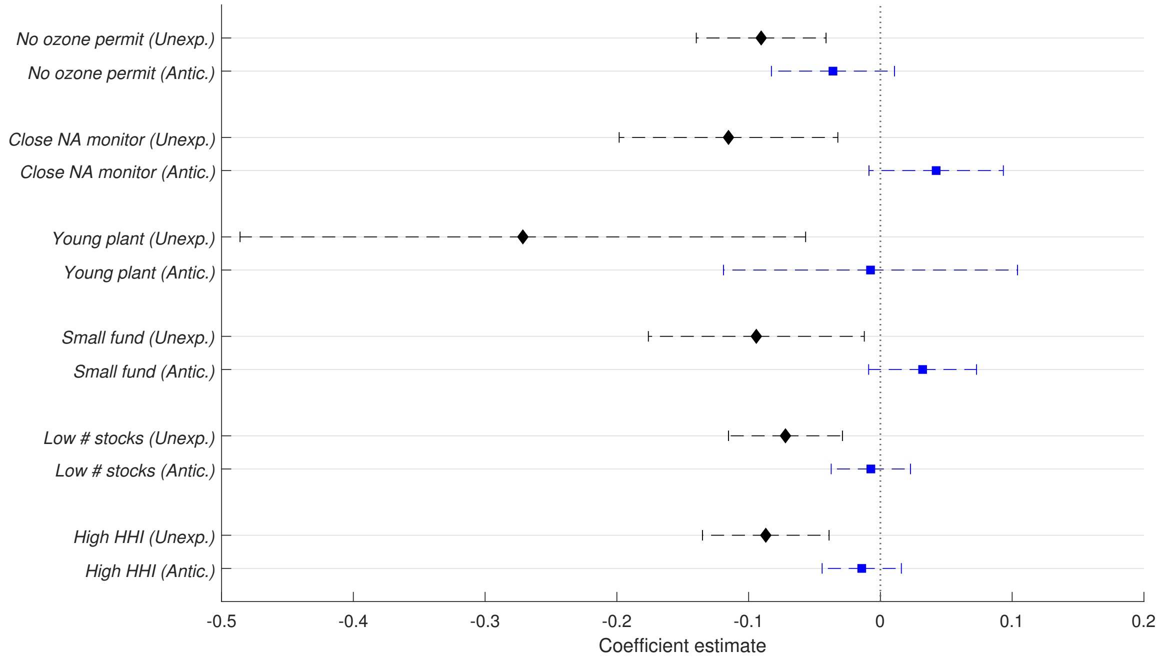
Figure 5
Dynamics of portfolio response to attainment redesignations.



This figure shows the point estimates (solid line) and 95% confidence intervals (dashed lines) of the coefficients for the interaction term, *Redesig ratio*$_t$ × *Ozone ratio*$_{t-1}$ × *Post Redesig(k)*, where k ranges from -4 to $+4$ quarters surrounding the attainment redesignation. The quarter before the attainment redesignation is the omitted category. The dependent variable is the weight (in percentage points) of a given stock in a given mutual fund's portfolio. *Redesig ratio* equals to the number of polluting plants located in counties redesignated to attainment for a given firm divided by the total number of nonattainment plants owned by the firm. *Ozone ratio* is the ozone air emissions for a given plant as a proportion of the plant's overall air emissions averaged across all nonattainment plants owned by a given firm.

Figure 6

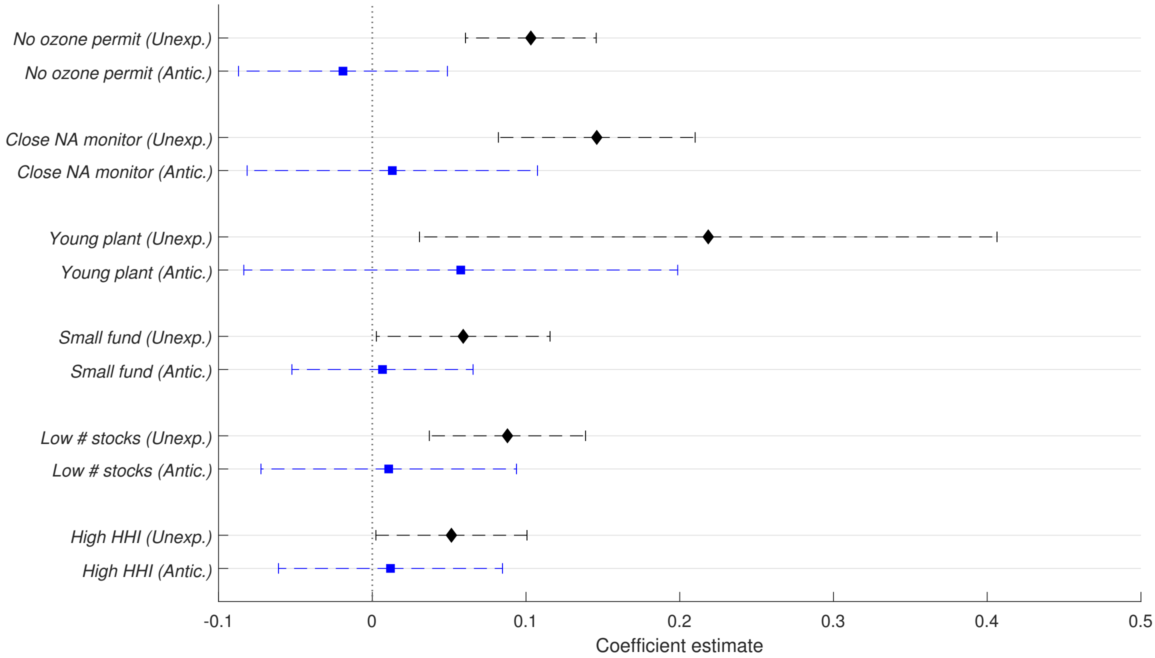
Heterogeneous portfolio responses to nonattainment designations.



This figure shows the point estimates and 95% confidence intervals of the coefficients for the triple interaction terms, *Unexp. NA* $ratio_t \times Ozone\ ratio_{t-1} \times Z$ (in black) and *Antic. NA* $ratio_t \times Ozone\ ratio_{t-1} \times Z$ (in blue), where Z refers to a set of firm and fund characteristics measured in the quarter before the nonattainment designation. We focus on two quarters before to two quarters after the nonattainment designation. The dependent variable is the change in the average weights (in percentage points) of a given stock in a given mutual fund's portfolio during the quarters after the nonattainment designation relative to the quarters before. *Unexp. NA ratio* equals to the number of polluting plants located in unexpected nonattainment counties for a given firm divided by the total number of plants owned by the firm. *Antic. NA ratio* equals to the number of polluting plants located in anticipated nonattainment counties for a given firm divided by the total number of plants owned by the firm. *Ozone ratio* is the ozone air emissions for a given plant as a proportion of the plant's overall air emissions averaged across all plants owned by a given firm. For each specification, the variable included in Z is listed on the vertical axis. *No ozone permit* is a dummy variable equal to one if a given firm does not have an ozone operating permit, and zero otherwise. *Close NA monitor* is a dummy variable equal to one if the average distance between the plants of a given firm to the closest nonattainment monitor is below the median, and zero otherwise. *Young plant* is a dummy variable equal to one if the average plant age of a given firm is between zero and five years, and zero otherwise. *Small fund* is a dummy variable equal to one for funds with a fund size below the median, and zero otherwise. *Low # stocks* is a dummy variable equal to one for funds with the number of stocks below the median, and zero otherwise. *High HHI* is a dummy variable equal to one for funds with HHI concentration above the median, and zero otherwise.

Figure 7

Heterogeneous portfolio responses to attainment redesignations.



This figure shows the point estimates and 95% confidence intervals of the coefficients for the triple interaction terms, *Unexp. redesig ratio*$_t$ × *Ozone ratio*$_{t-1}$ × Z (in black) and *Antic. redesig ratio*$_t$ × *Ozone ratio*$_{t-1}$ × Z (in blue), where Z refers to a set of firm and fund characteristics measured in the quarter before the attainment redesignation. We focus on two quarters before to two quarters after the attainment redesignation. The dependent variable is the change in the average weights (in percentage points) of a given stock in a given mutual fund's portfolio during the quarters after the attainment redesignation relative to the quarters before. *Unexp. redesig ratio* equals to the number of polluting plants located in unexpected attainment redesignation counties for a given firm divided by the total number of nonattainment plants owned by the firm. *Antic. redesig ratio* equals to the number of polluting plants located in anticipated attainment redesignation counties for a given firm divided by the total number of nonattainment plants owned by the firm. *Ozone ratio* is the ozone air emissions for a given plant as a proportion of the plant's overall air emissions averaged across all nonattainment plants owned by a given firm. For each specification, the variable included in Z is listed on the vertical axis. *No ozone permit* is a dummy variable equal to one if a given firm does not have an ozone operating permit, and zero otherwise. *Close NA monitor* is a dummy variable equal to one if the average distance between the plants of a given firm to the closest nonattainment monitor is below the median, and zero otherwise. *Young plant* is a dummy variable equal to one if the average plant age of a given firm is between zero and five years, and zero otherwise. *Small fund* is a dummy variable equal to one for funds with a fund size below the median, and zero otherwise. *Low # stocks* is a dummy variable equal to one for funds with the number of stocks below the median, and zero otherwise. *High HHI* is a dummy variable equal to one for funds with HHI concentration above the median, and zero otherwise.

Table 1
Distribution of county characteristics by state.

State	# Counties nonattainment	# Counties bump-up	# Counties redesignated	# Counties total	Avg NA (years)	Std. dev. NA (years)	Avg DV (ppm)	Std. dev. DV (ppm)
Alaska	0	0	0	29	0.00	0.00	0.050	0.007
Alabama	2	0	2	67	0.42	2.40	0.075	0.018
Arkansas	1	1	1	75	0.12	1.04	0.074	0.018
Arizona	4	2	2	15	3.07	8.02	0.076	0.010
California	42	28	5	58	16.67	12.54	0.084	0.025
Colorado	9	9	7	64	2.78	7.11	0.075	0.012
Connecticut	8	8	0	8	28.00	0.00	0.093	0.027
District of Columbia	1	1	1	1	28.00	0.00	0.090	0.024
Delaware	3	0	0	3	26.33	2.89	0.086	0.022
Florida	7	0	7	67	0.34	1.02	0.072	0.015
Georgia	23	20	23	159	2.64	7.22	0.082	0.023
Hawaii	0	0	0	5	0.00	0.00	0.045	0.008
Iowa	0	0	0	99	0.00	0.00	0.069	0.011
Idaho	0	0	0	44	0.00	0.00	0.068	0.011
Illinois	12	11	12	102	3.03	8.49	0.077	0.015
Indiana	24	2	24	92	1.83	4.54	0.079	0.017
Kansas	2	0	2	105	0.02	0.14	0.072	0.014
Kentucky	16	0	16	120	1.27	4.44	0.078	0.017
Louisiana	17	5	17	64	2.75	6.53	0.081	0.019
Massachusetts	14	0	0	14	23.36	1.34	0.082	0.021
Maryland	14	11	7	24	15.25	13.64	0.087	0.023
Maine	12	0	11	16	8.44	6.38	0.073	0.019
Michigan	39	0	39	83	3.33	4.09	0.082	0.019
Minnesota	0	0	0	87	0.00	0.00	0.065	0.010
Missouri	8	5	8	115	1.19	5.49	0.078	0.017
Mississippi	1	0	1	82	0.04	0.33	0.077	0.018
Montana	0	0	0	56	0.00	0.00	0.056	0.004
North Carolina	23	0	23	100	1.56	3.60	0.079	0.019
North Dakota	0	0	0	53	0.00	0.00	0.060	0.006
Nebraska	0	0	0	93	0.00	0.00	0.063	0.011
New Hampshire	7	0	6	10	10.80	9.68	0.078	0.019
New Jersey	21	12	0	21	28.00	0.00	0.087	0.022
New Mexico	1	0	0	33	0.33	1.91	0.071	0.011
Nevada	2	1	1	17	1.41	4.05	0.073	0.012
New York	30	28	0	62	10.39	11.70	0.080	0.020
Ohio	34	0	34	88	4.48	6.74	0.083	0.019
Oklahoma	0	0	0	77	0.00	0.00	0.075	0.013
Oregon	5	0	3	36	1.19	3.45	0.065	0.011
Pennsylvania	49	7	32	67	13.03	9.70	0.082	0.020
Rhode Island	5	0	0	5	23.00	0.00	0.088	0.023
South Carolina	2	0	2	46	0.28	1.77	0.076	0.018
South Dakota	0	0	0	66	0.00	0.00	0.064	0.007
Tennessee	14	1	14	95	1.05	2.79	0.081	0.020
Texas	23	21	4	254	1.96	6.61	0.082	0.023
Utah	7	0	2	29	0.66	1.80	0.076	0.015
Virginia	37	10	36	133	3.42	7.42	0.079	0.021
Vermont	0	0	0	14	0.00	0.00	0.073	0.016
Washington	4	0	4	39	0.51	1.54	0.064	0.013
Wisconsin	11	2	11	72	2.89	7.26	0.077	0.017
West Virginia	10	0	10	55	0.84	1.89	0.077	0.017
Wyoming	3	0	0	23	0.91	2.41	0.065	0.009

This table reports the number of counties ever obtained a nonattainment designation, number of counties ever experienced a bump-up classification, number of counties ever obtained an attainment redesignation, total number of counties, average nonattainment period, standard deviation of nonattainment period, average DV, and standard deviation of DV. The sample period is from 1991 to 2019.

Table 2
Summary statistics: Mutual funds and firms.

Variables	Mean	Median	Std. dev.	P25	P75	Obs.
Panel A: Mutual fund variables						
w	1.017	0.670	1.146	0.202	1.432	3,644,290
Shares	0.002	0.000	0.006	0.000	0.001	3,644,290
Traded value	10.229	1.261	55.271	0.278	5.376	3,644,290
Exit	0.043	0.000	0.202	0.000	0.000	426,695
Expense ratio	0.012	0.012	0.006	0.010	0.015	152,564
Turnover ratio	0.866	0.633	1.167	0.348	1.070	147,710
ln(Fund size)	5.027	5.088	2.014	3.665	6.438	175,403
Net flow	-0.083	-0.006	8.107	-0.060	0.057	168,523
Fund returns	0.008	0.011	0.096	-0.006	0.026	169,786
Number of stocks	97.584	63.000	157.886	34.000	103.000	161,637
Concentration	0.016	0.015	0.015	0.008	0.022	161,637
Mean portfolio return	0.033	0.030	0.036	0.013	0.050	142,696
Total portfolio risk	0.073	0.064	0.042	0.045	0.091	142,696
Alpha FF3	0.016	0.012	0.037	-0.001	0.028	142,696
Sharpe ratio	0.512	0.476	0.824	0.202	0.792	142,695
Panel B: Firm variables						
ln(Size)	7.079	7.132	2.211	5.662	8.526	65,792
ln(BM)	0.517	0.527	0.154	0.414	0.622	65,634
ROA	0.028	0.033	1.169	0.023	0.046	62,981
Leverage	0.271	0.221	0.220	0.102	0.394	64,063
Sales growth	0.214	0.057	11.401	-0.031	0.162	67,424
Momentum	1.163	1.102	0.560	0.889	1.330	63,726
Stock returns	0.039	0.029	0.235	-0.076	0.136	63,726
ROS	0.025	0.136	10.839	0.085	0.197	63,496
No ozone permit	0.253	0.000	0.435	0.000	1.000	1,632
NA monitor distance (km)	139.190	114.508	128.094	46.224	194.097	1,632
Young plant	0.056	0.000	0.229	0.000	0.000	1,632
Ozone ratio	0.343	0.272	0.334	0.000	0.578	15,619
NA ratio	0.341	0.243	0.358	0.000	0.542	1,632
Unexp. NA ratio	0.143	0.000	0.257	0.000	0.197	1,632
Antic. NA ratio	0.197	0.019	0.297	0.000	0.292	1,632
Bump ratio	0.408	0.267	0.351	0.125	0.667	864
Unexp. bump ratio	0.312	0.167	0.355	0.000	0.500	864
Antic. bump ratio	0.096	0.000	0.232	0.000	0.056	864
Redesig ratio	0.367	0.222	0.338	0.100	0.500	1,398
Unexp. redesig ratio	0.278	0.125	0.337	0.012	0.417	1,398
Antic. redesig ratio	0.089	0.000	0.223	0.000	0.030	1,398
SR activity	0.235	0.000	0.424	0.000	0.000	10,513
Total SR	6.401	7.944	6.002	0.000	11.674	10,513
High priority violation	0.087	0.000	0.336	0.000	0.000	10,513
Title V inspection	0.271	0.000	0.600	0.000	0.000	10,513
Stack test	0.246	0.000	0.704	0.000	0.000	10,513
Compliance evaluation	0.326	0.000	0.569	0.000	0.693	10,513
Fail stack test	0.021	0.000	0.144	0.000	0.000	10,513

Panel A reports summary statistics for fund-level variables. Panel B reports summary statistics for firm-level variables. Variable definitions are presented in Table A.1 in Appendix A. Std. dev. displays the standard deviation, P25 the first and P75 the third quartile of the respective variable. The sample period is from 1991 to 2019.

Table 3
Changes in portfolio weights in response to nonattainment designations.

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$_t$ × *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)
ln(Size)$_{t-1}$		-0.010***		-0.011***	-0.012***	-0.010***	-0.012***
		(-6.26)		(-6.41)	(-6.25)	(-6.30)	(-6.41)
ln(BM)$_{t-1}$		0.051***		0.054***	0.037**	0.059***	0.043***
		(4.15)		(4.09)	(2.50)	(4.56)	(2.94)
ROA$_{t-1}$		0.165***		0.197***	0.135**	0.196***	0.121*
		(2.77)		(3.08)	(1.99)	(3.09)	(1.83)
Leverage$_{t-1}$		0.013*		0.015*	0.008	0.018**	0.013
		(1.73)		(1.87)	(0.92)	(2.26)	(1.49)
Sales growth$_{t-1}$		0.008		0.010*	0.011*	0.008	0.009
		(1.58)		(1.77)	(1.85)	(1.49)	(1.53)
Momentum$_{t-1}$		-0.009***		-0.009***	-0.007***	-0.007***	-0.006**
		(-4.20)		(-3.82)	(-2.89)	(-3.39)	(-2.40)
Stock returns$_t$		0.050***		0.046***	0.035***	0.049***	0.039***
		(7.06)		(6.14)	(4.11)	(6.66)	(4.77)
Expense ratio$_{t-1}$			-0.999*	-1.341*	-0.895		
			(-1.90)	(-1.91)	(-1.17)		
Turnover ratio$_{t-1}$			-0.001	-0.001	-0.002		
			(-0.50)	(-0.48)	(-0.85)		
ln(Fund size)$_{t-1}$			-0.001	-0.001	0.000		
			(-0.64)	(-0.94)	(0.08)		
Net flow$_{t-1}$			0.028***	0.022*	0.019		
			(2.65)	(1.85)	(1.48)		
Fund returns$_{t-1}$			0.067	0.045	0.188		
			(0.46)	(0.28)	(1.10)		
Constant	-0.009***	0.049***	0.007	0.077***	0.086***	0.046**	0.070***
	(-5.18)	(2.89)	(0.61)	(3.42)	(3.34)	(2.54)	(3.46)
Fund × Stock F.E.	No	No	No	No	Yes	No	Yes
Fund × 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

This table reports the regression estimates from Equation (1) at the fund-firm-quarter level. We focus on two quarters before to two quarters after the nonattainment designation. The dependent variable is the change in the average weights (in percentage points) of a given stock in a given mutual fund's portfolio during the quarters after the nonattainment designation relative to the quarters before. *NA ratio* equals to the number of polluting plants located in nonattainment counties for a given firm divided by the total number of plants owned by the firm. *Ozone ratio* is the ozone air emissions for a given plant as a proportion of the plant's overall air emissions averaged across all plants owned by a given firm. For all specifications, standard errors are robust to heteroskedasticity and clustered at the fund-level; t-statistics are reported in the parenthesis. *, **, and *** indicate significance at the 10%, 5%, and 1% level, respectively. Variable definitions are presented in Table A.1 in Appendix A.

Table 4
Portfolio response to unexpected and anticipated nonattainment designations.

Dep. variable: Δw	(1)	(2)	(3)	(4)
Unexp. NA ratio$_t$	0.023***	0.029***	0.024***	0.029***
	(3.72)	(4.17)	(3.90)	(4.31)
Antic. NA ratio$_t$	0.010	0.011	0.006	0.007
	(1.55)	(1.60)	(1.05)	(1.00)
Ozone ratio$_{t-1}$	0.021***	0.014**	0.018***	0.013*
	(3.16)	(1.97)	(2.83)	(1.73)
Unexp. NA ratio$_t$ × *Ozone ratio*$_{t-1}$	-0.044***	-0.054***	-0.040***	-0.049***
	(-3.57)	(-4.16)	(-3.25)	(-3.82)
Antic. NA ratio$_t$ × *Ozone ratio*$_{t-1}$	-0.010	-0.007	-0.009	-0.007
	(-0.99)	(-0.58)	(-0.90)	(-0.56)
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	339,980	205,867	339,979	205,865
Adj R^2	0.04	0.01	0.06	0.05

This table reports portfolio responses to nonattainment designations when decomposed into an unexpected and anticipated component. We focus on two quarters before to two quarters after the nonattainment designation. The dependent variable is the change in the average weights (in percentage points) of a given stock in a given mutual fund's portfolio during the quarters after the nonattainment designation relative to the quarters before. *Unexp. NA ratio* equals to the number of polluting plants located in unexpected nonattainment counties for a given firm divided by the total number of plants owned by the firm. *Antic. NA ratio* equals to the number of polluting plants located in anticipated nonattainment counties for a given firm divided by the total number of plants owned by the firm. *Ozone ratio* is the ozone air emissions for a given plant as a proportion of the plant's overall air emissions averaged across all plants owned by a given firm. For all specifications, standard errors are robust to heteroskedasticity and clustered at the fund-level; t-statistics are reported in the parenthesis. *, **, and *** indicate significance at the 10%, 5%, and 1% level, respectively. Variable definitions are presented in Table A.1 in Appendix A.

Table 5
Changes in portfolio weights in response to bump-up classifications.

Panel A: Baseline bump-up classifications				
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

Panel B: Decomposition of bump-up classifications				
Dep. variable: Δw	(1)	(2)	(3)	(4)
Unexp. bump ratio$_t$	0.028***	0.024***	0.025***	0.018**
	(3.89)	(3.12)	(3.43)	(2.37)
Antic. bump ratio$_t$	0.017	0.013	0.015	0.011
	(1.54)	(1.01)	(1.27)	(0.85)
Ozone ratio$_{t-1}$	0.044***	0.041***	0.048***	0.044***
	(4.01)	(3.56)	(4.30)	(3.73)
Unexp. bump ratio$_t$ × *Ozone ratio*$_{t-1}$	-0.122***	-0.113***	-0.121***	-0.105***
	(-7.13)	(-6.25)	(-7.09)	(-5.83)
Antic. bump ratio$_t$ × *Ozone ratio*$_{t-1}$	-0.027	-0.016	-0.022	-0.011
	(-1.02)	(-0.57)	(-0.83)	(-0.39)
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	298,456	230,478	296,875	227,987
Adj R^2	0.03	0.01	0.09	0.05

This table examines the changes in portfolio weights in response to bump-up classifications. Panel A reports the regression estimates from Equation (3) at the fund-firm-quarter level while Panel B decomposes bump-up classifications into an unexpected and anticipated component. We focus on two quarters before to two quarters after the bump-up classification. The dependent variable is the change in the average weights (in percentage points) of a given stock in a given mutual fund's portfolio during the quarters after the bump-up classification relative to the quarters before. *Bump ratio* equals to the number of polluting plants located in nonattainment counties experiencing bump-ups for a given firm divided by the total number of nonattainment plants owned by the firm. *Unexp. bump ratio* equals to the number of polluting plants located in unexpected bump-up counties for a given firm divided by the total number of nonattainment plants owned by the firm. *Antic. bump ratio* equals to the number of polluting plants located in anticipated bump-up counties for a given firm divided by the total number of nonattainment plants owned by the firm. *Ozone ratio* is the ozone air emissions for a given plant as a proportion of the plant's overall air emissions averaged across all nonattainment plants owned by a given firm. For all specifications, standard errors are robust to heteroskedasticity and clustered at the fund-level; t-statistics are reported in the parenthesis. *, **, and *** indicate significance at the 10%, 5%, and 1% level, respectively. Variable definitions are presented in Table A.1 in Appendix A.

Table 6
Changes in portfolio weights in response to attainment redesignations.

Panel A: Baseline attainment redesignations				
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)
$Redesig\ ratio_t \times Ozone\ ratio_{t-1}$	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	110,277	73,818	96,748	55,582
Adj R^2	0.03	0.03	0.12	0.08

Panel B: Decomposition of attainment redesignations				
Dep. variable: Δw	(1)	(2)	(3)	(4)
$Unexp.\ redesig\ ratio_t$	-0.104***	-0.089***	-0.122***	-0.130***
	(-3.64)	(-2.93)	(-3.95)	(-4.53)
$Antic.\ redesig\ ratio_t$	-0.045	-0.045	-0.026	-0.018
	(-1.53)	(-1.41)	(-0.82)	(-0.65)
$Ozone\ ratio_{t-1}$	-0.103***	-0.082***	-0.104***	-0.094***
	(-4.65)	(-3.64)	(-4.02)	(-3.39)
$Unexp.\ redesig\ ratio_t \times Ozone\ ratio_{t-1}$	0.247***	0.366***	0.225***	0.159***
	(4.93)	(6.36)	(3.80)	(-3.19)
$Antic.\ redesig\ ratio_t \times Ozone\ ratio_{t-1}$	0.018	0.073	0.089	0.073
	(0.40)	(1.52)	(1.48)	(1.24)
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	110,277	73,818	96,748	55,582
Adj R^2	0.03	0.03	0.11	0.09

This table examines the changes in portfolio weights in response to attainment redesignations. Panel A reports the regression estimates from Equation (4) at the fund-firm-quarter level while Panel B decomposes attainment redesignations into an unexpected and anticipated component. We focus on two quarters before to two quarters after the attainment redesignation. The dependent variable is the change in the average weights (in percentage points) of a given stock in a given mutual fund's portfolio during the quarters after the attainment redesignation relative to the quarters before. *Redesig ratio* equals to the number of polluting plants located in counties redesignated to attainment for a given firm divided by the total number of nonattainment plants owned by the firm. *Unexp. redesig ratio* equals to the number of polluting plants located in unexpected attainment redesignation counties for a given firm divided by the total number of nonattainment plants owned by the firm. *Antic. redesig ratio* equals to the number of polluting plants located in anticipated attainment redesignation counties for a given firm divided by the total number of nonattainment plants owned by the firm. *Ozone ratio* is the ozone air emissions for a given plant as a proportion of the plant's overall air emissions averaged across all nonattainment plants owned by a given firm. For all specifications, standard errors are robust to heteroskedasticity and clustered at the fund-level; t-statistics are reported in the parenthesis. *, **, and *** indicate significance at the 10%, 5%, and 1% level, respectively. Variable definitions are presented in Table A.1 in Appendix A.

Table 7

Operating performance around nonattainment designations.

Dep. variable:	ROA_t		ROS_t		$Sales\ growth_t$	
	(1)	(2)	(3)	(4)	(5)	(6)
$NA\ ratio_t \times Post\ NA_t$	0.008***		0.023**		0.076*	
	(2.60)		(2.22)		(1.90)	
$Unexp.\ NA\ ratio_t \times Post\ NA_t$		0.009**		0.023**		0.060**
		(2.14)		(2.16)		(2.06)
$Antic.\ NA\ ratio_t \times Post\ NA_t$		0.004		0.015		0.014
		(0.86)		(1.33)		(0.45)
$Ozone\ ratio_{t-1} \times Post\ NA_t$	0.002	0.001	0.011*	0.007	0.039**	0.030
	(1.23)	(0.39)	(1.66)	(1.22)	(2.26)	(1.24)
$NA\ ratio_t \times Ozone\ ratio_{t-1} \times Post\ NA_t$	-0.015***		-0.037**		-0.112**	
	(-2.64)		(-2.47)		(-2.00)	
$Unexp.\ NA\ ratio_t \times Ozone\ ratio_{t-1} \times Post\ NA_t$		-0.014**		-0.034**		-0.120**
		(-2.44)		(-2.08)		(-2.04)
$Antic.\ NA\ ratio_t \times Ozone\ ratio_{t-1} \times Post\ NA_t$		0.003		-0.029		0.010
		(0.62)		(-1.01)		(0.22)
Stock controls	Yes	Yes	Yes	Yes	Yes	Yes
Stock F.E.	Yes	Yes	Yes	Yes	Yes	Yes
Industry F.E.	Yes	Yes	Yes	Yes	Yes	Yes
Year-Quarter F.E.	Yes	Yes	Yes	Yes	Yes	Yes
Observations	9,066	9,066	8,983	8,983	9,168	9,168
Adj R^2	0.61	0.62	0.55	0.52	0.06	0.06

This table reports the regression estimates from Equation (5) at the firm-quarter level. We focus on two quarters before to two quarters after the nonattainment designation. For brevity, only the post-nonattainment period variables are reported. The dependent variable is *ROA* in columns (1) and (2), *ROS* (return on sales) in columns (3) and (4), and *Sales growth* in columns (5) and (6). *NA ratio* equals to the number of polluting plants located in nonattainment counties for a given firm divided by the total number of plants owned by the firm. *Unexp. NA ratio* equals to the number of polluting plants located in unexpected nonattainment counties for a given firm divided by the total number of plants owned by the firm. *Antic. NA ratio* equals to the number of polluting plants located in anticipated nonattainment counties for a given firm divided by the total number of plants owned by the firm. *Ozone ratio* is the ozone air emissions for a given plant as a proportion of the plant's overall air emissions averaged across all plants owned by a given firm. *Post NA* is a dummy variable equal to one for the nonattainment designation quarter and the two following quarters. For all specifications, standard errors are robust to heteroskedasticity and clustered at the firm-level; t-statistics are reported in the parenthesis. *, **, and *** indicate significance at the 10%, 5%, and 1% level, respectively. Variable definitions are presented in Table A.1 in Appendix A.

Table 8
Underweighting and cumulative stock returns for top ozone emitting firms.

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)
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)

This table reports equal-weighted portfolio DGTW-adjusted cumulative abnormal returns. In each nonattainment designation quarter, we first identify top ozone emitting firms as those with an *Ozone ratio* value (defined as the ozone air emissions for a given plant as a proportion of the plant's overall air emissions averaged across all plants owned by a given firm) above the median. Independently, in each nonattainment designation quarter, we identify highly regulated (least regulated) firms as those with a *NA ratio* value (defined to be equal to the number of polluting plants located in nonattainment counties for a given firm divided by the total number of plants owned by the firm) above (below) the median. In Panel A (Panel B), we sort top ozone emitting firms that are highly regulated (least regulated) into tercile portfolios based on the average change in stock weight across all funds that hold the stock during the two quarters after the nonattainment designation relative to the two quarters before. We then compute equal-weighted DGTW-adjusted cumulative abnormal returns for each portfolio for one year before the event quarter (Year−1), one year after the event quarter (Year+1), two years after the event quarter (Year+2), and three years after the event quarter (Year+3). Tercile portfolio 1 is the most underweighted portfolio, whereas tercile portfolio 3 is the most overweighted portfolio. Portfolio $1-3$ represents a zero-investment long-short portfolio that is long tercile 1 and short tercile 3. Panel C shows the difference in returns between panels A and B. Standard errors are computed based on Newey-West correction with a lag length of 3; t-statistics are reported in the parenthesis. *, **, and *** indicate significance at the 10%, 5%, and 1% level, respectively.

Table 9
Underweighting and mutual fund investment performance around nonattainment designations.

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

This table examines the impact of the underweighting of ozone-polluting stocks during nonattainment designations on portfolio performance. The dependent variable in column (1) is the mean portfolio return calculated as the eight quarter forward (i.e., between quarter t and $t + 7$) rolling average of the quarterly holding returns. The dependent variable in column (2) is the total portfolio risk calculated as the eight quarter forward rolling standard deviation of the quarterly holding returns. The dependent variable in column (3) is the eight quarter forward rolling Sharpe ratio. The dependent variable in column (4) is the alpha from a Fama and French (1993) three factor model estimated using eight quarter forward rolling windows. In each nonattainment designation quarter, we first identify top ozone emitting firms as those with an *Ozone ratio* value (defined as the ozone air emissions for a given plant as a proportion of the plant's overall air emissions averaged across all plants owned by a given firm) above the median. Independently, in each nonattainment designation quarter, we identify highly regulated firms as those with a *NA ratio* value (defined to be equal to the number of polluting plants located in nonattainment counties for a given firm divided by the total number of plants owned by the firm) above the median. We then sort funds into terciles based on the average change in stock weight across all stocks in their portfolio that are classified as top ozone emitting and highly regulated firms during the two quarters after the nonattainment designation relative to the two quarters before. *Low* Δw is a dummy variable equal to one if a fund is in the lowest tercile. *Post*$[0, 2]$ is a dummy variable equal to one for quarters t, $t + 1$, and $t + 2$. *Post*$[3, 4]$, *Post*$[5, 6]$, *Post*$[7, 8]$, *Pre*$[-4, -3]$, and *Pre*$[-6, -5]$ are defined analogously. For all specifications, standard errors are robust to heteroskedasticity and clustered at the fund-level; t-statistics are reported in the parenthesis. *, **, and *** indicate significance at the 10%, 5%, and 1% level, respectively. Variable definitions are presented in Table A.1 in Appendix A.

Table 10
Underweighting and regulatory compliance costs of top ozone emitting firms around nonattainment designations.

	Pollution abatement		Regulatory enforcement				
Dep. variable:	SR activity	Total SR	High priority violation	Title V inspection	Stack test	Fail stack test	Compliance evaluation
	(1)	(2)	(3)	(4)	(5)	(6)	(7)
NA ratio$_t$	-0.140	0.984	-0.325*	-0.456	-0.458	-0.039	-0.056
	(-0.78)	(0.56)	(-1.70)	(-0.80)	(-0.92)	(-0.55)	(-0.15)
Underweight$_t$	0.007	-0.314	-0.149	0.318	0.071	0.067	-0.164
	(0.07)	(-0.24)	(-1.52)	(0.90)	(0.21)	(1.64)	(-0.90)
Post NA$_t$	0.120	0.884**	-0.015	0.226***	0.104*	0.014	0.152***
	(0.36)	(2.31)	(-0.52)	(4.21)	(1.87)	(1.01)	(4.74)
NA ratio$_t$ × *Underweight*$_t$	-0.146	-3.526	0.643*	-0.145	0.724	-0.103	0.709
	(-0.46)	(-0.78)	(1.82)	(-0.15)	(0.66)	(-1.01)	(1.22)
NA ratio$_t$ × *Post NA*$_t$	0.247	-0.066	0.099**	-0.148*	-0.030	-0.009	-0.117**
	(1.46)	(-0.10)	(2.07)	(-1.96)	(-0.40)	(-0.50)	(-2.41)
Underweight$_t$ × *Post NA*$_t$	-0.016	-1.291*	-0.229**	-0.327***	-0.453***	-0.056	-0.283***
	(-0.10)	(-1.66)	(-2.10)	(-2.91)	(-2.70)	(-1.49)	(-5.15)
NA ratio$_t$ × *Underweight*$_t$ × *Post NA*$_t$	0.177**	3.500**	0.361**	0.526**	0.759***	0.118**	0.246***
	(2.41)	(2.35)	(2.01)	(2.58)	(2.66)	(2.02)	(2.77)
Stock controls	Yes	Yes	Yes	Yes	Yes	Yes	Yes
Stock F.E.	Yes	Yes	Yes	Yes	Yes	Yes	Yes
Industry F.E.	Yes	Yes	Yes	Yes	Yes	Yes	Yes
Year F.E.	Yes	Yes	Yes	Yes	Yes	Yes	Yes
Observations	3,215	3,122	3,122	3,122	3,122	3,234	3,278
Adj R^2	0.11	0.06	0.56	0.71	0.61	0.12	0.69

This table reports the regression estimates from Equation (6) at the firm-year level for top ozone emitting firms. We focus on five years before to five years after the nonattainment designation. The dependent variable in column (1) is a dummy variable equal to one if a given firm undertakes source reduction activities related to ozone at plants located in nonattainment counties; in column (2) is the natural logarithm of one plus the amount of ozone air emissions that undergo source reduction of a given firm across all of its plants located in nonattainment counties; in column (3) is the natural logarithm of one plus the number of high priority violations of a given firm across all of its plants located in nonattainment counties; in column (4) is the natural logarithm of one plus the number of Title V inspections of a given firm across all of its plants located in nonattainment counties; in column (5) is the natural logarithm of one plus the number of stack tests of a given firm across all of its plants located in nonattainment counties; in column (6) is a dummy variable equal to one if a given firm operates a plant located in a nonattainment county that failed a stack test; and in column (7) is the natural logarithm of one plus the number of full compliance evaluations of a given firm across all of its plants located in nonattainment counties. In each nonattainment designation quarter, we identify top ozone emitting firms as those with an *Ozone ratio* value (defined as the ozone air emissions for a given plant as a proportion of the plant's overall air emissions averaged across all plants owned by a given firm) above the median. Then we sort top ozone emitting firms into terciles based on the average change in stock weight across all funds that hold the stock during the two quarters after the nonattainment designation relative to the two quarters before. *Underweight* is a dummy variable equal to one if a firm is in the lowest tercile. *NA ratio* equals to the number of polluting plants located in nonattainment counties for a given firm divided by the total number of plants owned by the firm. *Post NA* is a dummy variable equal to one for the nonattainment designation year and the five following years. For all specifications, standard errors are robust to heteroskedasticity and clustered at the firm-level; *t*-statistics are reported in the parenthesis. *, **, and *** indicate significance at the 10%, 5%, and 1% level, respectively. Variable definitions are presented in Table A.1 in Appendix A.

Appendix A: Variable definitions

Table A.1

Variable definitions.

Variable	Definitions	Data source
Mutual fund variables		
w	The weight (percentage points) of a given stock in a given mutual fund's portfolio at the end of quarter, where the weight is calculated as the dollar holdings of a stock divided by the total dollar holdings of all stocks in the mutual fund's portfolio.	Thomson Reuters mutual fund holdings (s12); CRSP
Δw	The change in the average weights (percentage points) of a given stock in a given mutual fund's portfolio during the two quarters after a nonattainment designation/bump-up classification/attainment redesignation relative to the two quarters before.	Thomson Reuters mutual fund holdings (s12); CRSP; Federal Register
Exit	A dummy variable equal to one if a given fund's portfolio completely divests a given stock in the two quarters after the nonattainment designation.	Thomson Reuters mutual fund holdings (s12)
Shares	The ratio of total number of shares of a given stock in a given mutual fund's portfolio to the total number of shares outstanding (in percentage points).	Thomson Reuters mutual fund holdings (s12); CRSP
Δ*Shares*	The change in the average ratio of total number of shares of a given stock in a given mutual fund's portfolio to the total number of shares outstanding (in percentage points) during the two quarters after a nonattainment designation/bump-up classification/attainment redesignation relative to the two quarters before.	Thomson Reuters mutual fund holdings (s12); CRSP; Federal Register
Traded value	The average dollar value (in millions) of the shares traded (bought or sold) of a given stock in a given mutual fund's portfolio during the two quarters after a nonattainment designation/bump-up classification/attainment redesignation relative to the two quarters before.	Thomson Reuters mutual fund holdings (s12); CRSP; Federal Register
Expense ratio	Fund expense ratio as reported in the CRSP Mutual Funds database. For funds with multiple share classes, the expense ratio is the weighted average using individual share classes' total net assets as the weight.	CRSP Mutual Funds
Turnover ratio	Fund turnover ratio as reported in the CRSP Mutual Funds database. For funds with multiple share classes, the turnover ratio is the weighted average using individual share classes' total net assets as the weight.	CRSP Mutual Funds
ln(Fund size)	The natural logarithm of one plus the sum of total net assets (TNA) of all fund classes.	CRSP Mutual Funds
Fund returns	The average net (after-expense) monthly return over a quarter. For funds with multiple share classes, fund returns are computed as the weighted average using individual share classes' total net assets as the weight.	CRSP Mutual Funds
Net flow	Net fund flows during quarter t is calculated as $100 \times (TNA_t - (1 + Fund\ returns_t) \times TNA_{t-1}) / TNA_{t-1}$.	CRSP Mutual Funds
Number of stocks	The number of stocks held in a given fund's portfolio.	Thomson Reuters mutual fund holdings (s12)
Concentration	The Herfindahl-Hirschman index (HHI) calculated based on the weights allocated to each stock in a given fund's portfolio.	Thomson Reuters mutual fund holdings (s12)
Mean portfolio return	The mean portfolio return is calculated as the eight quarter forward (i.e., between quarter t and $t+7$) rolling average of the quarterly holding returns.	Thomson Reuters mutual fund holdings (s12); CRSP
Total portfolio risk	The total portfolio risk is calculated as the eight quarter forward rolling standard deviation of the quarterly holding returns.	Thomson Reuters mutual fund holdings (s12); CRSP
Sharpe ratio	A given fund portfolio's eight quarter forward rolling Sharpe ratio.	Thomson Reuters mutual fund holdings (s12); CRSP
Alpha FF3	A given fund portfolio's alpha calculated from a Fama and French (1993) three factor model estimated using eight quarter forward rolling windows.	Thomson Reuters mutual fund holdings (s12); CRSP

Table A.1 continued

Variable	Definitions	Data source
Firm variables		
ln(Size)	The natural logarithm of market equity.	Compustat
ln(BM)	The natural logarithm of one plus the book-to-market ratio.	Compustat
ROA	Net income divided by total assets.	Compustat
Leverage	Total liabilities divided by total assets.	Compustat
Sales growth	Percentage quarterly change in firm sales, as compared to the same fiscal quarter of the prior year.	Compustat
Momentum	Cumulative 12-month return of a stock, excluding the immediate past month.	CRSP
Stock returns	Firm-level quarterly stock returns.	CRSP
ROS	Net income divided by sales.	Compustat
No ozone permit	A dummy variable equal to one if a given firm does not have an ozone operating permit.	ICIS-Air
NA monitor distance	The average distance (in km) between the plants of a given firm to the closest nonattainment monitor.	TRI; AQS
Young plant	A dummy variable equal to one if the average plant age of a given firm is between zero and five years.	NETS
Ozone ratio	The ozone air emissions for a given plant as a proportion of the plant's overall air emissions averaged across all plants owned by a given firm.	TRI
NA ratio	The number of polluting plants located in nonattainment counties for a given firm divided by the total number of plants owned by the firm.	TRI; Federal Register
Unexp. NA ratio	The number of polluting plants located in unexpected nonattainment counties for a given firm divided by the total number of plants owned by the firm.	TRI; Federal Register; AQS
Antic. NA ratio	The number of polluting plants located in anticipated nonattainment counties for a given firm divided by the total number of plants owned by the firm.	TRI; Federal Register; AQS
Bump ratio	The number of polluting plants located in nonattainment counties experiencing bump-ups for a given firm divided by the total number of nonattainment plants owned by the firm.	TRI; Federal Register
Unexp. bump ratio	The number of polluting plants located in unexpected bump-up counties for a given firm divided by the total number of nonattainment plants owned by the firm.	TRI; Federal Register; AQS
Antic. bump ratio	The number of polluting plants located in anticipated bump-up counties for a given firm divided by the total number of nonattainment plants owned by the firm.	TRI; Federal Register; AQS
Redesig ratio	The number of polluting plants located in counties redesignated to attainment for a given firm divided by the total number of nonattainment plants owned by the firm.	TRI; Federal Register
Unexp. redesig ratio	The number of polluting plants located in unexpected attainment redesignation counties for a given firm divided by the total number of nonattainment plants owned by the firm.	TRI; Federal Register; AQS
Antic. redesig ratio	The number of polluting plants located in anticipated attainment redesignation counties for a given firm divided by the total number of nonattainment plants owned by the firm.	TRI; Federal Register; AQS
SR activity	A dummy variable equal to one if a given firm undertakes source reduction activities related to ozone at plants located in nonattainment counties.	TRI P2
Total SR	The natural logarithm of one plus the amount of ozone air emissions that undergo source reduction of a given firm across all of its plants located in nonattainment counties.	TRI
High priority violation	The natural logarithm of one plus the number of high priority violations of a given firm across all of its plants located in nonattainment counties.	TRI; ICIS-Air
Title V inspection	The natural logarithm of one plus the number of Title V inspections of a given firm across all of its plants located in nonattainment counties.	TRI; ICIS-Air
Stack test	The natural logarithm of one plus the number of stack tests of a given firm across all of its plants located in nonattainment counties.	TRI; ICIS-Air
Compliance evaluation	The natural logarithm of one plus the number of full compliance evaluations of a given firm across all of its plants located in nonattainment counties.	TRI; ICIS-Air
Fail stack test	A dummy variable equal to one if a given firm operates a plant located in a nonattainment county that failed a stack test.	TRI; ICIS-Air

Internet Appendix For Online Publication Only

Appendix IA. RDD identifying assumptions

The identifying assumption of the RDD is that, around the NAAQS threshold, a county's designation status is as good as randomly assigned. In this section, we perform two standard tests for the RDD validity that counties cannot precisely manipulate the running variable so that their DVs are right below the NAAQS threshold (Lee & Lemieux, 2010). If this assumption is satisfied, then the variation in a county's designation status around the NAAQS threshold should be as good as that from a randomized experiment.

IA.1. Continuity in the distribution of design values

Having a DV below the NAAQS threshold is the main determining factor of a county's compliance status. Since being classified as nonattainment imposes costly regulatory actions to curb emissions, counties have a strong incentive to keep pollution levels below the threshold. Thus, one potential concern is that counties just above the threshold might try to manipulate their monitored ozone concentrations in order to be right below the threshold to avoid noncompliance. The first test that we conduct evaluates whether the distribution of DVs is continuous around the NAAQS threshold. Any discontinuity would suggest a nonrandom assignment of attainment versus nonattainment status around the threshold.

In practice, however, it is unlikely that counties could strategically manipulate their DVs. Since all counties are evaluated on the same standards, the EPA's federal enforcement power limits the states' ability to overlook non-compliers. Additionally, studies show that nonattainment designations often depend on weather patterns (Cleveland & Graedel, 1979; Cleveland, Kleiner, McRae, & Warner, 1976). Combined with the fact that ozone emissions are a result of complex chemical reactions in the atmosphere between pollutants such as volatile organic compounds and nitrogen oxides, it is extremely difficult for counties to manipulate their ozone concentration levels precisely. Lastly, ozone emissions that contribute to a county's DV not only originate from stationary sources such as the facilities examined in this paper, but also from mobile pollution sources (such as those from vehicles). Thus, even if there were a coordinated effort to manipulate ozone emissions by a group of facilities, it would still be unlikely to influence the DV of the entire county given other non-stationary emission sources.

Internet Appendix Figure IA.2 plots the local density of centered DVs, estimated separately on either side of the NAAQS threshold with the corresponding 95% confidence interval bounds, calculated using the plug-in estimator proposed by Cattaneo, Jansson, and Ma (2020). Observations on the left (right) of the vertical dashed line indicate that the county is in compliance with (violation of) the NAAQS threshold. If counties were manipulating their

DVs to strategically avoid nonattainment designations, one would expect to see a bunching of counties just below the NAAQS thresholds. As shown in the figure, there is no evidence for a discontinuous jump around the threshold. Using the density break test following Cattaneo et al. (2020),[33] we fail to reject the null hypothesis that counties are unable to manipulate their pollution levels in order to be right below the NAAQS threshold (p-value = 0.712).

IA.2. Preexisting differences

The second testable implication of the randomness assumption is that firms operating plants in counties whose DVs are immediately below or above the NAAQS threshold should be very similar on the basis of ex ante characteristics. In other words, if a county's designation status is as good as randomized, it should be orthogonal to firm characteristics prior to the designation.

In Internet Appendix Table IA.4, we examine whether there are any preexisting differences observable firm characteristics between firms that operate polluting plants in counties that are in violation of the NAAQS thresholds and those operating in counties that are in compliance. In addition to the main control variables on firm characteristics, we also include the following variables on financial constraints (KZ), defined as the Kaplan-Zingales index; cash ratio (*Cash*), calculated as cash divided by total assets; a dummy variable equal to one if a given firm operates plants that emit ozone core chemicals as defined by TRI, and zero otherwise (*Core chemical*);[34] a dummy variable equal to one if a given firm operates plants that hold operating permits for ozone emissions, and zero otherwise (*Permit*); a dummy variable equal to one if a given firm operates plants that engage in ozone source reduction activities (*Source reduction*); and a given firm's average ozone production ratio across all plants (*Production ratio*).[35] The data used to construct *Source reduction* and *Production ratio* are obtained from the EPA's Pollution Prevention (P2) database

In column (1) of Internet Appendix Table IA.4, we examine these characteristics in the year preceding the designation ($t-1$). In column (2), we examine the change in these characteristics between years $t-2$ and $t-1$. Both columns report the differences using a narrow window around the NAAQS threshold by computing the mean squared error optimal bandwidth following Calonico et al. (2014). As can be seen in both columns, there are no systematic or statistically significant differences in firm characteristics in the optimal neighborhood around the threshold, which lends support to our identification strategy.

[33] The density break test builds upon the more standard density manipulation test by McCrary (2008).

[34] Core chemicals are those that have consistent reporting requirements in TRI.

[35] This variable measures the change in output associated with the release of a chemical in a given year. For example, if a chemical is used in the manufacturing of refrigerators, the production ratio for year t is given by $\frac{\#\text{Refrigerators produced}_t}{\#\text{Refrigerators produced}_{t-1}}$. If the chemical is used as part of an activity and not directly in the production of goods, then the production ratio represents a change in the activity. For instance, if a chemical is used to clean molds, then the production ratio for year t is given by $\frac{\#\text{Molds cleaned}_t}{\#\text{Molds cleaned}_{t-1}}$.

Appendix IB. Additional robustness tests

IB.1. Alternative pre- and post-nonattainment periods

To ensure our results are not driven by a particular window around nonattainment designations, we perform tests with alternative windows around the nonattainment designation quarter. We work with the following windows around the nonattainment designation quarter: $[-1, +1]$, $[-1, +2]$, $[-1, +3]$, $[-2, +1]$, $[-2, +3]$, and $[-3, +3]$. The coefficient on *NA ratio* × *Ozone ratio* is always negative and statistically significant (unreported), which is similar to our baseline results in Table 3.

IB.2. Alternative measures of portfolio response

A potential concern regarding our analysis is that the decrease in portfolio weights of ozone-polluting firms may be driven by a temporary drop in the stock price of these firms in response to nonattainment designations, even if funds do not sell stocks of these firms. Although we argue that such concerns are mitigated in our setting since Equation (1) controls for stock returns, and such drop in stock prices would require systematic market-wide selling of ozone-polluting stocks across a broader investor base above and beyond mutual funds, we consider a variety of different dependent variables.

First, we consider scenarios where the fund completely divests its holdings of ozone-polluting stocks in response to nonattainment designations. Specifically, we define the dummy variable *Exit* to be equal to one if a given fund's portfolio holds a given stock in the pre-nonattainment designation quarters, but divests it in the post-nonattainment designation quarters, and zero otherwise. We estimate the same regression as in Equation (1), but with *Exit* as the dependent variable. The results are reported in Internet Appendix Table IA.6. Across all specifications of fixed effects, the coefficients on *NA ratio* × *Ozone ratio* are positive and statistically significant, indicating that funds are more likely to completely divest their holdings of heavy ozone-polluting stocks affected by nonattainment designations. Economically, a one standard deviation increase in *NA ratio* and *Ozone ratio* increases the probability of divestment by 0.18%, corresponding to an increase of 4.17% relative to the sample mean.

We also use two other alternative dependent variables in estimating Equation (1): Δ*Shares*, defined as the change in the average ratio of total number of shares of a given stock in a given mutual fund's portfolio to the total number of shares outstanding (in percentage points) during the post-nonattainment designation quarters relative to the pre-nonattainment designation quarters; and *Traded value*, defined as the average dollar value (in millions) of the shares traded (bought or sold) of a given stock in a given mutual fund's portfolio during the post-nonattainment designation quarters relative to the pre-nonattainment designation quarters. Columns (1) and (2) of Internet Appendix Table IA.7 present the results using Δ*Shares* as the dependent variable, while columns (3) and (4) use *Traded value*. Across all columns, we find that the coefficients on *NA ratio* × *Ozone ratio* are negative and statistically significant, indicating that funds tend to sell more shares of heavy ozone-polluting firms exposed to nonattainment regulations. These results suggest that our main findings are not simply driven by temporary share price drops of polluting firms.

We use Δ*Shares* and *Traded value* as alternative measures of portfolio response to bump-up classifications (Internet Appendix Table IA.15) and attainment redesignations (Internet Appendix Table IA.16). Our findings remain qualitatively unchanged.

IB.3. Toxicity-weighted ozone emissions

Since the toxicity of each chemical varies, we account for the inherent heterogeneity of each chemical by multiplying the mass of each chemical by its toxicity, which is obtained from EPA's Risk-Screening Environmental Indicator model. Since we only focus on air emissions, we follow Gamper-Rabindran (2006) and use the inhalation toxicity weight. We define *TW ozone ratio* as the toxicity-weighted ozone air emissions for a given plant as a proportion of the plant's overall toxicity-weighted air emissions, averaged across all plants owned by a given firm. We replicate the analyses involving changes in portfolio weights in response to nonattainment designations (Internet Appendix Table IA.8) using *TW ozone ratio* and find robust results.

IB.4. Core ozone chemicals

To mitigate the concern of reporting errors in the TRI data, we also run the regression involving changes in portfolio weights in response to nonattainment designations for only core ozone chemicals. Core chemical groups exclude any chemicals that were added to or removed from the TRI list during our sample period. The idea is that using core chemical groups ensures that there were consistent reporting requirements for chemicals in the analysis across all reporting years. In addition, routine inspections and audits should work more effectively in ensuring accurate reporting for the core chemical groups. Internet Appendix Table IA.9 shows that our results hold in this robustness check.

IB.5. Offsite ozone emissions

Since nonattainment designations regulate a facility's onsite ozone emissions, funds should not hedge against nonattainment regulatory risk by adjusting portfolio weights based on a polluting firm's offsite ozone emissions. To test this, we construct the variable *Offsite ozone ratio*, which is the offsite ozone air emissions for a given plant as a proportion of the plant's overall offsite air emissions, averaged across all plants owned by a given firm. The coefficient on *NA ratio* $\times$ *Offsite ozone ratio* is statistically insignificant in Internet Appendix Table IA.10, confirming the falsification test.

IB.6. Alternative measures of exposure to nonattainment designations

One potential concern in our main analysis is that the independent variable that measures a firm's exposure to nonattainment designations, *NA ratio*, may not reflect the relative importance of a firm's different polluting plants. For example, it may be more costly if polluting plants that generate the majority of sales for a given firm are located in nonattainment counties. As robustness checks, we construct two additional independent variables by using employee- and sales-weighted *NA ratio*. Specifically, we use plant-level employee and sales data from NETS to construct the variables *Employee NA ratio* and *Sales NA ratio*. The former equals to the employee-weighted number of polluting plants located in nonattainment counties for a given firm divided by the total number of employees across all polluting plants owned by the firm. The latter equals to the sales-weighted number of polluting plants located in nonattainment counties for a given firm divided by the total amount of sales across all polluting plants owned by the firm. Internet Appendix Table IA.11 shows that our main results remain intact when using these two variables in place of *NA ratio* in the estimation of Equation (1).

IB.7. Self-selection

Although nonattainment designations are typically regarded as exogenous events in the environmental economics literature (Greenstone, 2002; Walker, 2011, 2013), firms may self-select into nonattainment counties if they expect the regulation to be implemented. For example, firms that are already equipped with the latest pollution abatement technology may expect an implementation of mandatory pollution requirement that increases the cost of its local competitors, and hence, choose to continue operations in nonattainment counties. If this is the case, the change of attainment status is then self-selected. To address the potential self-selection problem, we conduct a Heckman (1979) two-stage least squares estimation for correction. In the first stage, we use a probit model to predict realized nonattainment status. The main independent variable is the county's noncompliance based on prior year DVs and following Curtis (2020), we include four additional predictors of nonattainment status. These variables are measured pre-nonattainment and include the county's employment levels, employment changes, NO_x emissions to employment ratio, and MSA status. Column (1) of Internet Appendix Table IA.12 presents the first-stage estimation results. As expected, a county's noncompliance based on prior year DVs positively predicts subsequent realized nonattainment status. Consistent with Curtis (2020), we also find that employment levels, NO_x emissions to employment ratio, and MSA status are all positive predictors of nonattainment status.

In the second stage, we use the predicted probability of a county's nonattainment status to compute the inverse Mills ratio $IMR_{c,t}$ for county c in event year t. Since the IMR absorbs hidden factors that may affect a county's implementation of regulation, a firm's proportion of nonattainment plants is affected by the hidden factors in all counties where it operates polluting plants. To aggregate these factors' effect at the firm-level, we construct the firm-event year weighted average Heckman correction variable $HC_{s,t}$ using county-event year level IMR as follows:

$$HC_{s,t} = \frac{\sum_c \#Plant_{s,c,t} \times IMR_{c,t}}{\sum_c \#Plant_{s,c,t}} \tag{IB.1}$$

for firm s, county c, and year t. The variable $\#Plant_{s,c,t}$ is the number of polluting plants that firm s operates in county c in year t. Then, we include the variable $HC_{s,t}$ in our estimation of Equation (1). The results are presented in columns (2) to (5) of Internet Appendix Table IA.12. The findings are qualitatively unchanged from Table 3 and more importantly, the Heckman correction variable enters insignificantly in all specifications, indicating that the self-selection problem is not a major concern in these analyses.

IB.8. Funds' sustainability

Studies have shown that funds that are more environmentally conscious ("sustainable funds") may attempt to engage with portfolio firms on environmental issues such as pollution (Azar et al., 2021; Choi et al., 2021; Gibson et al., 2021). Thus, it could be possible that our results are driven by more sustainable funds divesting from ozone-polluting firms to exert pressure on firms' management to reduce their emissions. We argue, however, that such a scenario is unlikely to impact on our results since emission reductions due to nonattainment regulations are binding for polluting firms, which diminish funds' incentives to engage. Nonetheless, we conduct a robustness check, whereby we estimate Equation (1), but condition on a fund's pre-nonattainment sustainability by including the variable *vw-Environment score* and its interactions with *NA ratio* and *Ozone ratio*.

Following Gibson et al. (2021), we define *vw-Environment score* as a fund's portfolio holding value-weighted *Environment score* (difference between the average strength and concern environment scores from MSCI KLD for a given firm). A higher value of *vw-Environment score* implies that the fund's portfolio is more environmentally sustainable. We present the results in Internet Appendix Table IA.13. Across all columns, the coefficients on *NA ratio* × *Ozone ratio* remain negative and statistically significant, while those on the triple interaction term *NA ratio* × *Ozone ratio* × *vw-Environment score* are all statistically insignificant, implying that there are no differences in the degree of underweighting of heavy ozone-polluting firms exposed to nonattainment designations between more sustainable funds and less sustainable funds.

IB.9. Demand for ESG fund flows

We examine the possibility that the underweighting of ozone-polluting firms is driven by funds competing for ESG investment flows (Ceccarelli et al., 2021; Hartzmark & Sussman, 2019; Riedl & Smeets, 2017). Specifically, nonattainment designations may induce fund managers to shift their holdings toward firms with less emissions in order to attract ESG-conscious investors. Since ESG investment flows is based on investors' perceptions of a fund portfolio's overall "greenness", funds should shift their holdings toward low ozone-polluting firms regardless of their exposure to nonattainment designations. This explanation, however, is inconsistent with our results because we show that firms *overweight* heavy ozone-polluting firms when they are not exposed to nonattainment designations. Nonetheless, we check whether funds that allocate a substantial portion of holdings to heavy ozone-polluting firms that are exposed to nonattainment designations experience lower investment flows in the subsequent quarters.

Our specification is the following panel regression:

$$\begin{aligned} \textit{Net flow}_{m,t+k} &= \beta_0 + \beta_1 \textit{vw-NA ratio}_{m,t} + \beta_2 \textit{vw-Ozone ratio}_{m,t} + \beta_3 \textit{vw-NA ratio}_{m,t} \\ &\times \textit{vw-Ozone ratio}_{m,t} + \text{Controls} + \text{F.E.} + \varepsilon_{m,t+1} \end{aligned} \tag{IB.2}$$

for fund m and quarter t. The dependent variable is a fund's net flow in quarter $t+k$, where $k = 1, 2$. *vw-NA ratio*$_t$ and *vw-Ozone ratio*$_t$ are the mutual fund's portfolio holding value-weighted *NA ratio* and *Ozone ratio*, respectively, in quarter t. We include fund control variables and also value-weighted average characteristics of the portfolio's stock holdings. We use fund and year-quarter fixed effects. If funds compete for ESG investment flows, then we expect β_3 to be negative. As shown in Internet Appendix Table IA.14, none of the coefficients on *vw-NA ratio* × *vw-Ozone ratio* are statistically significant, indicating that demand for ESG investment flows does not appear to be driving our results.

IB.10. Underweighting and buy-and-hold stock returns

Barber and Lyon (1997) argue that buy-and-hold stock returns (BHARs) are more suitable to detect abnormal stock returns over long holding horizons (e.g., one to five years). Thus, we replicate the analysis in Section 6.2, but use DGTW-adjusted BHARs instead of CARs. The results remain qualitatively unchanged in Internet Appendix Table IA.17.

IB.11. Underweighting and regulatory compliance costs of low ozone emitting firms

Section 7 documents that underweighted *top* ozone-polluting firms operating a majority of plants in nonattainment counties are subject to more regulatory costs as measured by their engagement in pollution abatement and regulatory enforcement. Since *low* ozone emitting firms are less impacted by the NAAQS, regardless of their exposure to nonattainment designations, a falsification test is that the source reduction activities and regulatory enforcement of underweighted *low* ozone-polluting firms should not depend on their exposure to nonattainment designations. Consistent with this prediction, Internet Appendix Table IA.18 estimates Equation (6) using the sample of low ozone emitting firms and find that the coefficients on *NA ratio* × *Underweight* × *Post NA* are all statistically indistinguishable from zero. The only exception is the number of Title V inspections, where the coefficient is positive and statistically significant, but much smaller in magnitude when compared to Table 10.

IB.12. Is underweighting causing a change in firm behavior?

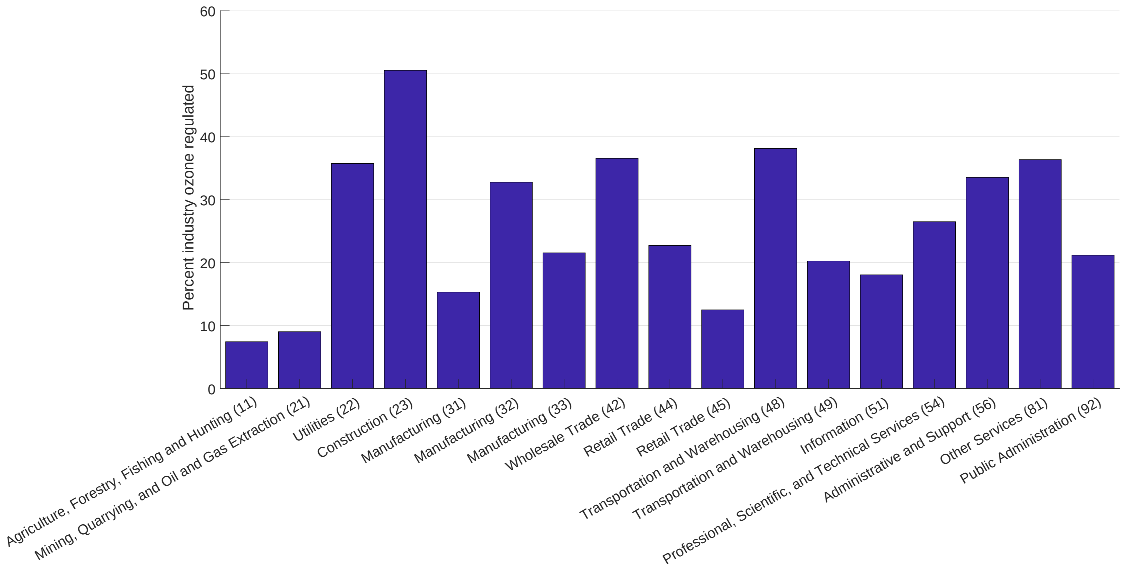
Kim et al. (2019) show that local institutional ownership is negatively related to facility toxic release. Thus, it would be problematic if the underweighting of top ozone-polluting firms causes a change in firms' emission behavior, which in turn impacts on their regulatory status. To alleviate these concerns, we estimate Equation (6) using a series of outcome variables that measures the amount of ozone emissions, number of EPA formal actions, and dollar amount of penalties across nonattainment plants for a given firm.[36] The intuition is that if underweighting causes a change in firm behavior, then it should lead to an observable

[36]The EPA formal actions are judicial and administrative enforcement cases. The nature of these cases pertains to violations of various environmental statutes. Cases can result in penalties (either at the federal and/or local state level), which are fines for violating a statute. There could also be other monetary losses including supplemental environmental project (SEP) and compliance costs. These costs are not fines paid to the EPA, but rather are costs incurred to resolve the violations and/or in lieu of paying a fine. We obtain data on formal administrative and judicial cases from EPA's Integrated Compliance Information System for Federal Civil Enforcement Case Data (ICIS FE&C).

change in the aforementioned outcome variables in the post-nonattainment period. Internet Appendix Table IA.19 shows that the coefficients on *NA ratio* × *Underweight* × *Post NA* are all statistically indistinguishable from zero, implying that the change in regulatory status of top ozone-polluting firms is stemming from their exposure to nonattainment designations rather than from the underweighting itself.

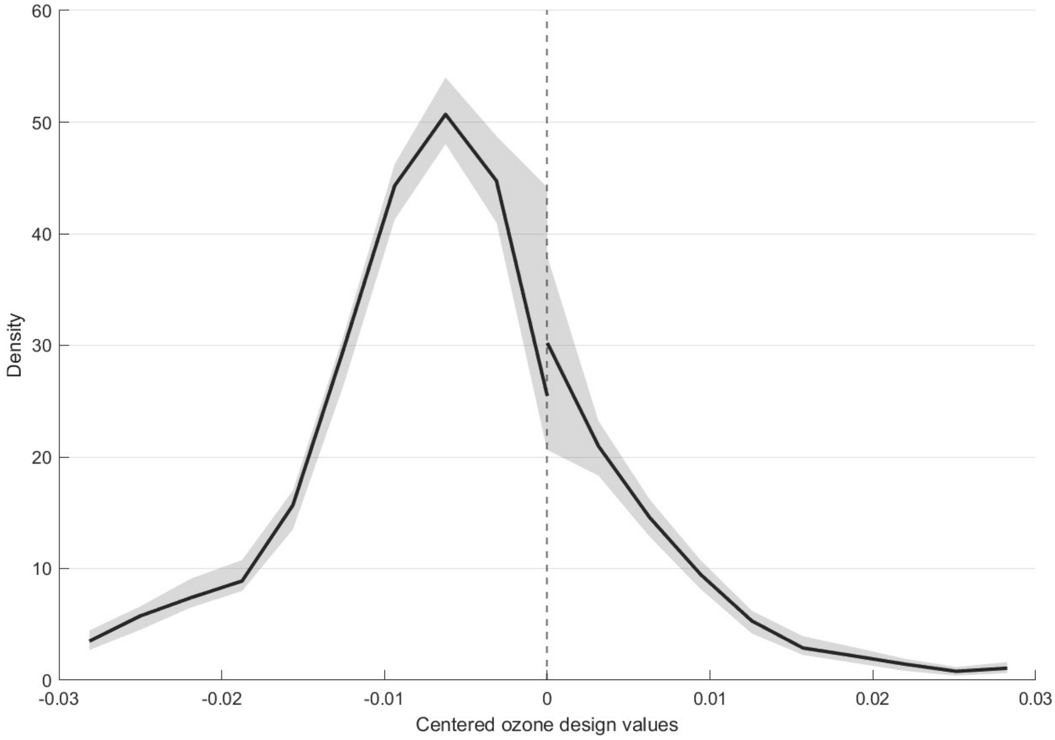
Figure IA.1

Fraction of ozone plants by industry in nonattainment counties.



This figure shows the fraction of ozone emitting plants by major industry (categorized using two-digit industry NAICS codes) in nonattainment counties.

Figure IA.2
Density break test around NAAQS thresholds.



This figure presents the density of observations by the distance to the ozone NAAQS threshold. The horizontal axis shows the centered DVs around zero by subtracting the NAAQS threshold from the DVs. The dashed vertical line at zero represents the NAAQS threshold for ozone nonattainment status. Observations on the right (left) of the line indicate that the county is in violation of (compliance with) the NAAQS threshold. The solid black lines represent the local density on either side of the NAAQS threshold and the shaded gray area corresponds to the 95% confidence interval bounds, calculated using the plug-in estimator proposed by Cattaneo et al. (2020). We fail to reject the null hypothesis that there is no break in density around the threshold, with a p-value of 0.712.

Table IA.1
Ozone NAAQS.

Standard	Effective date	Averaging time	Threshold (ppm)	Form
1-Hour Ozone (1979)	January 6, 1992	1 hour	0.12	Attainment is defined when the expected number of days per calendar year, with maximum hourly average concentration greater than 0.12 ppm, is equal to or less than 1
8-Hour Ozone (1997)	June 15, 2004	8 hours	0.08	Annual fourth-highest daily maximum 8-hr concentration, averaged over 3 years
8-Hour Ozone (2008)	July 20, 2012	8 hours	0.075	Annual fourth-highest daily maximum 8-hr concentration, averaged over 3 years
8-Hour Ozone (2015)	August 3, 2018	8 hours	0.070	Annual fourth-highest daily maximum 8-hr concentration, averaged over 3 years

This table provides basic descriptions of the ozone NAAQS used in our study. Standard refers to the name of the ozone NAAQS. Effective date is the date on which the standard is effectively implemented as stated in the Federal Register. Averaging time is the sampling frequency of the ozone concentration used to calculate DVs. Threshold refers to the DV value which if exceeded, then the county is considered to be in nonattainment. This value is measured in parts per million (ppm). Form is the rule used to compute the DVs for the relevant ozone standard. The 1-Hour Ozone (1979) standard was proposed in 1979 and implemented effective January 6, 1992. The 8-Hour Ozone (1997) was proposed in 1997 and implemented effective June 15, 2004. The 8-Hour Ozone (2008) was proposed in 2008 and implemented effective July 20, 2012. The 8-Hour Ozone (2015) was proposed in 2015 and implemented effective August 3, 2018. This table is adapted from `https://www.epa.gov/ground-level-ozone-pollution/timeline-ozone-national-ambient-air-quality-standards-naaqs`.

Table IA.2
TRI industry composition.

NAICS	Description	Proportion (%)
325	Chemical Manufacturing	12.970
332	Fabricated Metal Product Manufacturing	12.644
336	Transportation Equipment Manufacturing	8.222
311	Food Manufacturing	7.942
333	Machinery Manufacturing	7.252
331	Primary Metal Manufacturing	6.733
334	Computer and Electronic Product Manufacturing	5.665
221	Utilities	4.958
327	Nonmetallic Mineral Product Manufacturing	4.709
326	Plastics and Rubber Products Manufacturing	4.430
424	Merchant Wholesalers, Nondurable Goods	3.531
321	Wood Product Manufacturing	3.144
322	Paper Manufacturing	3.128
335	Electrical Equipment, Appliance, and Component Manufacturing	3.044
324	Petroleum and Coal Products Manufacturing	2.740
562	Waste Management and Remediation Services	2.020
339	Miscellaneous Manufacturing	1.739
337	Furniture and Related Product Manufacturing	1.407
212	Mining (except Oil and Gas)	0.819
323	Printing and Related Support Activities	0.814
313	Textile Mills	0.614
312	Beverage and Tobacco Product Manufacturing	0.585
314	Textile Product Mills	0.299
316	Leather and Allied Product Manufacturing	0.110
811	Repair and Maintenance	0.090
454	Nonstore Retailers	0.079
315	Apparel Manufacturing	0.052
541	Professional, Scientific, and Technical Services	0.052
213	Support Activities for Mining	0.029
488	Support Activities for Transportation	0.027
113	Forestry and Logging	0.025
112	Animal Production and Aquaculture	0.024
493	Warehousing and Storage	0.020
486	Pipeline Transportation	0.013
532	Rental and Leasing Services	0.013
551	Management of Companies and Enterprises	0.009
481	Air Transportation	0.008
237	Heavy and Civil Engineering Construction	0.005
423	Merchant Wholesalers, Durable Goods	0.005
425	Wholesale Electronic Markets and Agents and Brokers	0.005
444	Building Material and Garden Equipment and Supplies Dealers	0.004
445	Food and Beverage Stores	0.004
561	Administrative and Support Services	0.004
531	Real Estate	0.003
211	Oil and Gas Extraction	0.002
442	Furniture and Home Furnishings Stores	0.002
484	Truck Transportation	0.002
511	Publishing Industries (except Internet)	0.002
812	Personal and Laundry Services	0.002
115	Support Activities for Agriculture and Forestry	0.002

This table reports the three-digit NAICS industries in TRI that are included in our sample. Proportion refers to the fraction that is represented in our sample.

Table IA.3
Noncompliant design values and probability of nonattainment.

	Full sample	1-Hour Ozone (1979)	8-Hour Ozone (1997)	8-Hour Ozone (2008)	8-Hour Ozone (2015)
Dep. variable: $NA_{c,t+1}$	(1)	(2)	(3)	(4)	(5)
$Noncompliance_{c,t}$	0.651***	0.597***	0.604***	0.781***	0.718***
	(17.14)	(4.03)	(8.86)	(9.03)	(8.02)
Kernel	Rec.	Rec.	Rec.	Rec.	Rec.
Bandwidth type	Opt.	Opt.	Opt.	Opt.	Opt.
Bandwidth estimate	0.009	0.009	0.008	0.005	0.005
Covariates	Yes	Yes	Yes	Yes	Yes
Observations	1,493	133	378	243	326

This table presents the probability of nonattainment designation when a given county's DV is in violation of the NAAQS threshold. We estimate the local linear regression specification given in Equation (2) using the mean squared error optimal bandwidth with rectangular kernels following Calonico et al. (2014). Column (1) uses the full sample of nonattainment designations based on revisions in the NAAQS threshold for all four ozone standards. Columns (2) to (5) use the subsample of nonattainment designations based on revisions in the NAAQS threshold for the 1-Hour Ozone (1979), 8-Hour Ozone (1997), 8-Hour Ozone (2008), and 8-Hour Ozone (2015) standards, respectively. $NA_{c,t+1}$ is a dummy variable equal to one if county c is designated nonattainment in year $t+1$, and zero otherwise. $Noncompliance_{c,t}$ is a dummy variable equal to one if county c's DV is in violation of the NAAQS threshold in year t, and zero otherwise. County-level covariates include the natural logarithm of one plus the employment levels in a given county, a given county's NO_x emissions to employment ratio, the change in a given county's employment levels, and a dummy variable equal to one if the county is located in a MSA. For all specifications, standard errors are clustered by county and bias-corrected following Calonico et al. (2014); t-statistics are reported in the parenthesis. *, **, and *** indicate significance at the 10%, 5%, and 1% level, respectively. Variable definitions are presented in Table A.1 in Appendix A.

Table IA.4
Preexisting differences in firm characteristics.

	Year $(t-1)$	Δ from year $(t-2)$ to $(t-1)$
	(1)	(2)
ln(Size)	0.156	-0.034
	(0.176)	(0.047)
ln(BM)	-0.012	0.000
	(0.011)	(0.009)
ROA	-0.001	-0.001
	(0.001)	(0.001)
Leverage	-0.017	0.007
	(0.012)	(0.010)
Sales growth	-0.059	0.017
	(0.083)	(0.018)
KZ	-0.090	0.254
	(0.219)	(0.313)
Cash	0.010	0.000
	(0.008)	(0.003)
Momentum	0.005	0.011
	(0.059)	(0.078)
Stock returns	0.011	-0.051
	(0.053)	(0.086)
Core chemical	-0.032	0.001
	(0.034)	(0.012)
Permit	0.002	-0.001
	(0.059)	(0.002)
Source reduction	0.007	-0.010
	(0.018)	(0.020)
Production ratio	-0.018	0.036
	(0.037)	(0.054)
Sample:	Opt.	Opt.

This table examines the differences in observable firm characteristics between firms that operate polluting plants in counties that are in violation of the NAAQS thresholds and those operating in counties that are in compliance. In column (1), these characteristics are measured in the year preceding the nonattainment designation $(t-1)$. Column (2) considers the change in these characteristics between years $t-2$ and $t-1$. Both columns report the differences using a narrow window around the NAAQS threshold by computing the mean squared error optimal bandwidth following Calonico et al. (2014). For all specifications, standard errors are clustered by county, bias-corrected following Calonico et al. (2014), and reported in the parenthesis. *, **, and *** indicate significance at the 10%, 5%, and 1% level, respectively. Variable definitions are presented in Table A.1 in Appendix A.

Table IA.5
Changes in portfolio weights in response to nonattainment designations using the full triple difference-in-differences specification.

Dep. variable: w	(1)	(2)
$NA\ ratio_t \times Post\ NA_t$	0.024***	0.036***
	(5.26)	(6.66)
$Ozone\ ratio_{t-1} \times Post\ NA_t$	0.028***	0.027***
	(13.35)	(12.79)
$NA\ ratio_t \times Ozone\ ratio_{t-1} \times Post\ NA_t$	-0.055***	-0.056***
	(-6.88)	(-7.02)
Stock controls	Yes	Yes
Fund controls	Yes	No
Fund × Stock F.E.	No	Yes
Fund × Year-Quarter F.E.	No	Yes
Fund F.E.	Yes	No
Stock F.E.	Yes	No
Year-Quarter F.E.	Yes	No
Observations	1,699,935	1,699,905
Adj R^2	0.52	0.53

This table reports the regression estimates using the full triple difference-in-differences version of Equation (1) at the fund-firm-quarter level. We focus on two quarters before to two quarters after the nonattainment designation. The dependent variable is the weight (in percentage points) of a given stock in a given mutual fund's portfolio. *NA ratio* equals to the number of polluting plants located in nonattainment counties for a given firm divided by the total number of plants owned by the firm. *Ozone ratio* is the ozone air emissions for a given plant as a proportion of the plant's overall air emissions averaged across all plants owned by a given firm. *Post NA* is a dummy variable equal to one for the post-nonattainment designation quarters, and zero otherwise. For all specifications, standard errors are robust to heteroskedasticity and clustered at the fund-level; t-statistics are reported in the parenthesis. *, **, and *** indicate significance at the 10%, 5%, and 1% level, respectively. Variable definitions are presented in Table A.1 in Appendix A.

Table IA.6
Portfolio exits in response to nonattainment designations.

Dep. variable: *Exit*	(1)	(2)	(3)	(4)
$NA\ ratio_t$	-0.013***	-0.010**	-0.014***	-0.010**
	(-3.90)	(-2.54)	(-3.90)	(-2.50)
$Ozone\ ratio_{t-1}$	-0.019***	-0.011**	-0.019***	-0.011**
	(-5.08)	(-2.55)	(-4.97)	(-2.53)
$NA\ ratio_t \times Ozone\ ratio_{t-1}$	0.015***	0.013**	0.015***	0.014**
	(2.57)	(2.00)	(2.63)	(2.09)
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	339,980	205,867	339,979	205,865
Adj R^2	0.03	0.01	0.04	0.02

This table reports the regression estimates from Equation (1) at the fund-firm-quarter level, except the dependent variable is *Exit*, a dummy variable equal to one if a given fund's portfolio completely divests a given stock in the quarters after the nonattainment designation. We focus on two quarters before to two quarters after the nonattainment designation. *NA ratio* equals to the number of polluting plants located in nonattainment counties for a given firm divided by the total number of plants owned by the firm. *Ozone ratio* is the ozone air emissions for a given plant as a proportion of the plant's overall air emissions averaged across all plants owned by a given firm. For all specifications, standard errors are robust to heteroskedasticity and clustered at the fund-level; *t*-statistics are reported in the parenthesis. *, **, and *** indicate significance at the 10%, 5%, and 1% level, respectively. Variable definitions are presented in Table A.1 in Appendix A.

Table IA.7

Alternative measures of portfolio response to nonattainment designations.

Dep. variable:	$\Delta Shares$		*Traded value*	
	(1)	(2)	(3)	(4)
$NA\ ratio_t$	0.028^{**}	0.036^{***}	0.378^{***}	0.455^{***}
	(2.19)	(2.63)	(4.16)	(3.66)
$Ozone\ ratio_{t-1}$	0.022^{*}	0.024^{*}	0.361^{***}	0.496^{***}
	(1.65)	(1.72)	(3.25)	(3.00)
$NA\ ratio_t \times Ozone\ ratio_{t-1}$	-0.009^{***}	-0.010^{**}	-0.711^{***}	-0.931^{***}
	(-2.72)	(-1.96)	(-3.84)	(-3.58)
Stock controls	Yes	Yes	Yes	Yes
Fund controls	Yes	No	Yes	No
Fund × Stock F.E.	No	Yes	No	Yes
Fund × Year-Quarter F.E.	No	Yes	No	Yes
Fund F.E.	Yes	No	Yes	No
Stock F.E.	Yes	No	Yes	No
Year-Quarter F.E.	Yes	No	Yes	No
Observations	339,980	205,865	339,980	205,865
Adj R^2	0.03	0.03	0.01	0.06

This table reports the regression estimates from Equation (1) at the fund-firm-quarter level using alternative dependent variables. We focus on two quarters before to two quarters after the nonattainment designation. The dependent variable in columns (1) and (2) is the change in the average ratio of total number of shares of a given stock in a given mutual fund's portfolio to the total number of shares outstanding (in percentage points) during the quarters after the nonattainment designation relative to the quarters before. The dependent variable in columns (3) and (4) is the average dollar value (in millions) of the shares traded (bought or sold) of a given stock in a given mutual fund's portfolio during the quarters after the nonattainment designation relative to the quarters before. *NA ratio* equals to the number of polluting plants located in nonattainment counties for a given firm divided by the total number of plants owned by the firm. *Ozone ratio* is the ozone air emissions for a given plant as a proportion of the plant's overall air emissions averaged across all plants owned by a given firm. For all specifications, standard errors are robust to heteroskedasticity and clustered at the fund-level; t-statistics are reported in the parenthesis. *, **, and *** indicate significance at the 10%, 5%, and 1% level, respectively. Variable definitions are presented in Table A.1 in Appendix A.

Table IA.8

Changes in portfolio weights in response to nonattainment designations using toxicity-weighted emissions.

Dep. variable: Δw	(1)	(2)	(3)	(4)
$NA\ ratio_t$	0.017***	0.020***	0.013***	0.018***
	(6.29)	(3.38)	(2.59)	(3.02)
$TW\ ozone\ ratio_{t-1}$	0.024***	0.015**	0.012**	0.012*
	(9.37)	(2.18)	(2.02)	(1.86)
$NA\ ratio_t \times TW\ ozone\ ratio_{t-1}$	-0.019***	-0.020**	-0.018**	-0.019**
	(-3.65)	(-1.99)	(-2.00)	(-1.98)
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	339,982	205,728	339,142	205,865
Adj R^2	0.03	0.01	0.06	0.05

This table reports the regression estimates from Equation (1) at the fund-firm-quarter level using toxicity-weighted ozone emissions. We focus on two quarters before to two quarters after the nonattainment designation. The dependent variable is the change in the average weights (in percentage points) of a given stock in a given mutual fund's portfolio during the quarters after the nonattainment designation relative to the quarters before. *NA ratio* equals to the number of polluting plants located in nonattainment counties for a given firm divided by the total number of plants owned by the firm. *TW ozone ratio* is the toxicity-weighted ozone air emissions for a given plant as a proportion of the plant's overall toxicity-weighted air emissions averaged across all plants owned by a given firm. For all specifications, standard errors are robust to heteroskedasticity and clustered at the fund-level; t-statistics are reported in the parenthesis. *, **, and *** indicate significance at the 10%, 5%, and 1% level, respectively. Variable definitions are presented in Table A.1 in Appendix A.

Table IA.9
Changes in portfolio weights in response to nonattainment designations using the subsample of plants emitting core ozone chemicals.

Dep. variable: Δw	(1)	(2)	(3)	(4)
$NA\ ratio_t$	0.050***	0.069***	0.051***	0.066***
	(5.20)	(5.55)	(4.79)	(5.44)
$Ozone\ ratio_{t-1}$	0.016**	0.013**	0.011*	0.011*
	(1.99)	(2.05)	(1.88)	(1.77)
$NA\ ratio_t \times Ozone\ ratio_{t-1}$	-0.051***	-0.061***	-0.044***	-0.060***
	(-3.95)	(-3.93)	(-3.29)	(-3.95)
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	249,294	149,511	249,293	149,506
Adj R^2	0.04	0.01	0.06	0.04

This table reports the regression estimates from Equation (1) at the fund-firm-quarter level for the subsample of firms with plants emitting core ozone chemicals. We focus on two quarters before to two quarters after the nonattainment designation. The dependent variable is the change in the average weights (in percentage points) of a given stock in a given mutual fund's portfolio during the quarters after the nonattainment designation relative to the quarters before. *NA ratio* equals to the number of polluting plants located in nonattainment counties for a given firm divided by the total number of plants owned by the firm. *Ozone ratio* is the ozone air emissions for a given plant as a proportion of the plant's overall air emissions averaged across all plants owned by a given firm. For all specifications, standard errors are robust to heteroskedasticity and clustered at the fund-level; t-statistics are reported in the parenthesis. *, **, and *** indicate significance at the 10%, 5%, and 1% level, respectively. Variable definitions are presented in Table A.1 in Appendix A.

Table IA.10

Changes in portfolio weights in response to nonattainment designations using offsite emissions.

Dep. variable: Δw	(1)	(2)	(3)	(4)
$NA\ ratio_t$	0.007	0.002	0.007	-0.001
	(1.49)	(0.23)	(1.47)	(-0.17)
$Offsite\ ozone\ ratio_{t-1}$	-0.001	-0.006	0.000	-0.005
	(-0.05)	(-0.51)	(0.03)	(-0.48)
$NA\ ratio_t \times Offsite\ ozone\ ratio_{t-1}$	0.020	0.014	0.015	0.009
	(1.54)	(1.02)	(1.24)	(0.68)
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	339,980	205,867	339,979	205,865
Adj R^2	0.04	0.01	0.06	0.05

This table reports the regression estimates from Equation (1) at the fund-firm-quarter level using offsite ozone emissions. We focus on two quarters before to two quarters after the nonattainment designation. The dependent variable is the change in the average weights (in percentage points) of a given stock in a given mutual fund's portfolio during the quarters after the nonattainment designation relative to the quarters before. *NA ratio* equals to the number of polluting plants located in nonattainment counties for a given firm divided by the total number of plants owned by the firm. *Offsite ozone ratio* is the offsite ozone air emissions for a given plant as a proportion of the plant's overall offsite air emissions averaged across all plants owned by a given firm. For all specifications, standard errors are robust to heteroskedasticity and clustered at the fund-level; t-statistics are reported in the parenthesis. *, **, and *** indicate significance at the 10%, 5%, and 1% level, respectively. Variable definitions are presented in Table A.1 in Appendix A.

Table IA.11

Changes in portfolio weights in response to nonattainment designations using employee- and sales-weighted *NA ratio*.

Panel A: Employee-weighted NA ratio				
Dep. variable: Δw	(1)	(2)	(3)	(4)
Employee NA ratio$_t$	0.018***	0.019***	0.017***	0.018**
	(2.90)	(2.76)	(2.73)	(2.55)
Ozone ratio$_{t-1}$	0.022***	0.021***	0.022***	0.021***
	(3.60)	(3.22)	(3.57)	(3.27)
Employee NA ratio$_t$ × *Ozone ratio*$_{t-1}$	-0.043***	-0.040***	-0.044***	-0.042***
	(-4.81)	(-4.07)	(-4.90)	(-4.22)
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	318,256	189,720	318,255	189,718
Adj R^2	0.04	0.01	0.06	0.05

Panel B: Sales-weighted NA ratio				
Dep. variable: Δw	(1)	(2)	(3)	(4)
Sales NA ratio$_t$	0.014**	0.015**	0.013**	0.014**
	(2.40)	(2.27)	(2.25)	(2.10)
Ozone ratio$_{t-1}$	0.021***	0.020***	0.021***	0.020***
	(3.40)	(3.03)	(3.36)	(3.08)
Sales NA ratio$_t$ × *Ozone ratio*$_{t-1}$	-0.040***	-0.038***	-0.042***	-0.039***
	(-4.61)	(-3.88)	(-4.67)	(-4.02)
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	318,256	189,720	318,255	189,718
Adj R^2	0.05	0.01	0.06	0.05

This table reports the regression estimates from Equation (1) at the fund-firm-quarter level using employee- and sales-weighted *NA ratio* in panels A and B, respectively. We focus on two quarters before to two quarters after the nonattainment designation. The dependent variable is the change in the average weights (in percentage points) of a given stock in a given mutual fund's portfolio during the quarters after the nonattainment designation relative to the quarters before. *Employee NA ratio* equals to the employee-weighted number of polluting plants located in nonattainment counties for a given firm divided by the total number of employees across all polluting plants owned by the firm. *Sales NA ratio* equals to the sales-weighted number of polluting plants located in nonattainment counties for a given firm divided by the total amount of sales across all polluting plants owned by the firm. *Ozone ratio* is the ozone air emissions for a given plant as a proportion of the plant's overall air emissions averaged across all plants owned by a given firm. For all specifications, standard errors are robust to heteroskedasticity and clustered at the fund-level; *t*-statistics are reported in the parenthesis. *, **, and *** indicate significance at the 10%, 5%, and 1% level, respectively. Variable definitions are presented in Table A.1 in Appendix A.

Table IA.12

Changes in portfolio weights in response to nonattainment designations using Heckman correction.

	First stage		Second stage			
Dep. variable: NA_t	(1)	Dep. variable: Δw	(2)	(3)	(4)	(5)
$Noncompliance_{t-1}$	0.753***	$NA\ ratio_t$	0.018***	0.020***	0.016***	0.020***
	(10.81)		(3.35)	(3.37)	(3.14)	(3.41)
$ln(County\ emp)_{t-1}$	0.823***	$Ozone\ ratio_{t-1}$	0.023***	0.014*	0.020***	0.015*
	(3.40)		(3.39)	(1.85)	(3.04)	(1.96)
$Nox\text{-}county\ emp\ ratio_{t-1}$	0.153**	$NA\ ratio_t \times Ozone\ ratio_{t-1}$	-0.026***	-0.027**	-0.025***	-0.028***
	(2.02)		(-2.77)	(-2.56)	(-2.58)	(-2.67)
$\Delta County\ emp_{t-1}$	0.002	*HC*	0.017	0.018	0.016	0.016
	(0.26)		(1.59)	(1.48)	(1.55)	(1.30)
MSA	3.397***					
	(21.30)	Stock controls	Yes	Yes	Yes	Yes
		Fund controls	Yes	Yes	No	No
		Fund × Stock F.E.	No	Yes	No	Yes
Year F.E.	Yes	Fund × Year-Quarter F.E.	No	No	Yes	Yes
County F.E.	Yes	Fund F.E.	Yes	No	No	No
Observations	16,707	Stock F.E.	Yes	No	Yes	No
Adj R^2	0.27	Year-Quarter F.E.	Yes	Yes	No	No
		Observations	337,148	205,323	337,147	205,321
		Adj R^2	0.04	0.01	0.06	0.05

This table reports the two-stage Heckman correction estimation results for Equation (1) at the fund-firm-quarter level. Column (1) presents the first-stage results using a probit model where the dependent variable, NA_t, is a dummy variable equal to one if a given county is in nonattainment in year t, and zero otherwise. The explanatory variables are $Noncompliance_{t-1}$, which is a dummy variable equal to one if a given county's DV is in violation of the NAAQS threshold in year $t-1$, and zero otherwise; $ln(County\ emp)_{t-1}$, defined as the natural logarithm of one plus the employment levels in a given county; $NOx\text{-}county\ emp\ ratio_{t-1}$, defined as a given county's NO_x emissions to employment ratio; $\Delta County\ emp_{t-1}$, equal to the change in a given county's employment levels; and *MSA*, which is a dummy variable equal to one if the county is located in a MSA. Columns (2) to (5) present the second-stage results where a Heckman correction variable, *HC*, is included in all regressions. We focus on two quarters before to two quarters after the nonattainment designation. The dependent variable is the change in the average weights (in percentage points) of a given stock in a given mutual fund's portfolio during the quarters after the nonattainment designation relative to the quarters before. *NA ratio* equals to the number of polluting plants located in nonattainment counties for a given firm divided by the total number of plants owned by the firm. *Ozone ratio* is the ozone air emissions for a given plant as a proportion of the plant's overall air emissions averaged across all plants owned by a given firm. For all specifications, standard errors are robust to heteroskedasticity and clustered at the fund-level; t-statistics are reported in the parenthesis. *, **, and *** indicate significance at the 10%, 5%, and 1% level, respectively. Variable definitions are presented in Table A.1 in Appendix A.

Table IA.13

Changes in portfolio weights in response to nonattainment designations conditional on funds' sustainability.

Dep. variable: Δw	(1)	(2)	(3)	(4)
$NA\ ratio_t$	0.013**	0.015**	0.014**	0.015**
	(2.23)	(2.05)	(2.30)	(2.04)
$Ozone\ ratio_{t-1}$	0.019**	0.031***	0.020**	0.033***
	(2.40)	(3.13)	(2.48)	(3.23)
$vw\text{-}Environment\ score_{t-1}$	0.002	0.004		
	(0.08)	(0.18)		
$NA\ ratio_t \times Ozone\ ratio_{t-1}$	-0.027**	-0.050***	-0.030***	-0.051***
	(-2.36)	(-3.44)	(-2.60)	(-3.52)
$NA\ ratio_t \times vw\text{-}Environment\ score_{t-1}$	0.023	0.087	0.013	0.082
	(0.64)	(1.61)	(0.32)	(1.54)
$Ozone\ ratio_{t-1} \times vw\text{-}Environment\ score_{t-1}$	-0.019	-0.066	-0.018	-0.045
	(-0.74)	(-1.59)	(-0.63)	(-1.62)
$NA\ ratio_t \times Ozone\ ratio_{t-1} \times vw\text{-}Environment\ score_{t-1}$	-0.179	-0.208	-0.154	-0.274
	(-1.43)	(-0.87)	(-1.20)	(-1.20)
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	274,756	158,975	274,755	158,973
Adj R^2	0.04	0.01	0.06	0.04

This table examines how funds adjust their portfolio holdings of ozone-polluting firms exposed to nonattainment designations, conditional on funds' sustainability. We focus on two quarters before to two quarters after the nonattainment designation. The dependent variable is the change in the average weights (in percentage points) of a given stock in a given mutual fund's portfolio during the quarters after the nonattainment designation relative to the quarters before. *vw-Environment score* is the mutual fund's portfolio holding value-weighted *Environment score*, which is defined as the difference between the average strength and concern environment scores for a given firm. *NA ratio* equals to the number of polluting plants located in nonattainment counties for a given firm divided by the total number of plants owned by the firm. *Ozone ratio* is the ozone air emissions for a given plant as a proportion of the plant's overall air emissions averaged across all plants owned by a given firm. For all specifications, standard errors are robust to heteroskedasticity and clustered at the fund-level; t-statistics are reported in the parenthesis. *, **, and *** indicate significance at the 10%, 5%, and 1% level, respectively. Variable definitions are presented in Table A.1 in Appendix A.

Table IA.14

The effect of portfolio exposure to nonattainment designations on fund flows.

Dep. variable:	*Net flow*$_{t+1}$	*Net flow*$_{t+2}$
	(1)	(2)
vw-NA ratio$_t$	0.302	0.114
	(0.60)	(0.25)
vw-Ozone ratio$_t$	-1.182	0.847
	(-1.16)	(1.57)
vw-NA ratio$_t$ × *vw-Ozone ratio*$_t$	-1.629	-4.200
	(-0.66)	(-1.37)
Value-weighted stock controls	Yes	Yes
Fund controls	Yes	Yes
Fund F.E.	Yes	Yes
Year-Quarter F.E.	Yes	Yes
Observations	119,820	119,654
Adj R^2	0.30	0.04

This table reports the panel regression estimates from Equation (IB.2) at the fund-quarter level over the sample period 1991 to 2019. The dependent variables in columns (1) and (2) are the mutual fund flows in quarter $t+1$ and $t+2$, respectively. *vw-NA ratio*$_t$ is the mutual fund's portfolio holding value-weighted *NA ratio* in quarter t. *vw-Ozone ratio*$_t$ is the mutual fund's portfolio holding value-weighted *Ozone ratio* in quarter t. For all specifications, standard errors are robust to heteroskedasticity and clustered at the fund-level; t-statistics are reported in the parenthesis. *, **, and *** indicate significance at the 10%, 5%, and 1% level, respectively. Variable definitions are presented in Table A.1 in Appendix A.

Table IA.15
Alternative measures of portfolio response to bump-up classifications.

Dep. variable:	Δ*Shares*		*Traded value*	
	(1)	(2)	(3)	(4)
Bump ratio$_t$	0.005***	0.005***	0.154	0.194
	(3.32)	(2.91)	(1.30)	(1.35)
Ozone ratio$_{t-1}$	0.003*	0.003*	0.826***	1.117***
	(1.70)	(1.66)	(3.53)	(4.14)
Bump ratio$_t$ × *Ozone ratio*$_{t-1}$	-0.007***	-0.006**	-1.332***	-1.548***
	(-2.76)	(-2.13)	(3.69)	(-4.04)
Stock controls	Yes	Yes	Yes	Yes
Fund controls	Yes	No	Yes	No
Fund × Stock F.E.	No	Yes	No	Yes
Fund × Year-Quarter F.E.	No	Yes	No	Yes
Fund F.E.	Yes	No	Yes	No
Stock F.E.	Yes	No	Yes	No
Year-Quarter F.E.	Yes	No	Yes	No
Observations	298,456	227,987	298,456	227,987
Adj R^2	0.01	0.08	0.01	0.03

This table reports the regression estimates from Equation (3) at the fund-firm-quarter level using alternative dependent variables. We focus on two quarters before to two quarters after the bump-up classification. The dependent variable in columns (1) and (2) is the change in the average ratio of total number of shares of a given stock in a given mutual fund's portfolio to the total number of shares outstanding (in percentage points) during the quarters after the bump-up classification relative to the quarters before. The dependent variable in columns (3) and (4) is the average dollar value (in millions) of the shares traded (bought or sold) of a given stock in a given mutual fund's portfolio during the quarters after the bump-up classification relative to the quarters before. *Bump ratio* equals to the number of polluting plants located in nonattainment counties experiencing bump-ups for a given firm divided by the total number of nonattainment plants owned by the firm. *Ozone ratio* is the ozone air emissions for a given plant as a proportion of the plant's overall air emissions averaged across all nonattainment plants owned by a given firm. For all specifications, standard errors are robust to heteroskedasticity and clustered at the fund-level; t-statistics are reported in the parenthesis. *, **, and *** indicate significance at the 10%, 5%, and 1% level, respectively. Variable definitions are presented in Table A.1 in Appendix A.

Table IA.16
Alternative measures of portfolio response to attainment redesignations.

Dep. variable:	$\Delta Shares$		$Traded\ value$	
	(1)	(2)	(3)	(4)
$Redesig\ ratio_t$	-0.033***	-0.033**	-0.733***	-1.666***
	(-2.99)	(-2.54)	(-2.66)	(-3.23)
$Ozone\ ratio_{t-1}$	-0.011**	-0.005	-1.036***	-3.685***
	(-2.04)	(-0.80)	(-2.60)	(-3.14)
$Redesig\ ratio_t \times Ozone\ ratio_{t-1}$	0.048***	0.042**	1.532***	2.870***
	(2.94)	(2.14)	(2.98)	(2.68)
Stock controls	Yes	Yes	Yes	Yes
Fund controls	Yes	No	Yes	No
Fund × Stock F.E.	No	Yes	No	Yes
Fund × Year-Quarter F.E.	No	Yes	No	Yes
Fund F.E.	Yes	No	Yes	No
Stock F.E.	Yes	No	Yes	No
Year-Quarter F.E.	Yes	No	Yes	No
Observations	110,277	55,582	110,277	55,582
Adj R^2	0.03	0.01	0.02	0.23

This table reports the regression estimates from Equation (4) at the fund-firm-quarter level using alternative dependent variables. We focus on two quarters before to two quarters after the attainment redesignation. The dependent variable in columns (1) and (2) is the change in the average ratio of total number of shares of a given stock in a given mutual fund's portfolio to the total number of shares outstanding (in percentage points) during the quarters after the attainment redesignation relative to the quarters before. The dependent variable in columns (3) and (4) is the average dollar value (in millions) of the shares traded (bought or sold) of a given stock in a given mutual fund's portfolio during the quarters after the attainment redesignation relative to the quarters before. *Redesig ratio* equals to the number of polluting plants located in counties redesignated to attainment for a given firm divided by the total number of nonattainment plants owned by the firm. *Ozone ratio* is the ozone air emissions for a given plant as a proportion of the plant's overall air emissions averaged across all nonattainment plants owned by a given firm. For all specifications, standard errors are robust to heteroskedasticity and clustered at the fund-level; t-statistics are reported in the parenthesis. *, **, and *** indicate significance at the 10%, 5%, and 1% level, respectively. Variable definitions are presented in Table A.1 in Appendix A.

Table IA.17

Underweighting and buy-and-hold stock returns for top ozone emitting firms.

Panel A: Highly regulated firms

	Horizon			
Tercile	Year−1	Year+1	Year+2	Year+3
1 (Underweighted)	0.014	-0.041*	-0.033	-0.017
	(0.65)	(-1.91)	(-0.76)	(-0.32)
2	-0.074**	0.016	0.079*	0.159***
	(-2.33)	(0.44)	(1.73)	(2.74)
3 (Overweighted)	-0.010	0.078***	0.166***	0.218***
	(-0.42)	(2.77)	(3.70)	(3.63)
1 − 3	0.023	-0.119***	-0.199***	-0.235***
	(0.75)	(-3.36)	(-3.18)	(-2.90)

Panel B: Least regulated firms

	Horizon			
Tercile	Year−1	Year+1	Year+2	Year+3
1 (Underweighted)	-0.024	0.006	0.047	0.038
	(-0.91)	(0.23)	(0.73)	(0.53)
2	-0.088***	-0.003	0.096	0.055
	(-3.11)	(-0.06)	(1.35)	(0.68)
3 (Overweighted)	0.014	0.021	0.059	0.120*
	(0.55)	(0.88)	(1.47)	(1.89)
1 − 3	-0.037	-0.016	-0.012	-0.083
	(-1.04)	(-0.46)	(-0.15)	(-0.87)

Panel C: Difference between highly and least regulated firms

	Horizon			
Tercile	Year−1	Year+1	Year+2	Year+3
1 (Underweighted)	0.037	-0.047	-0.081	-0.055
	(1.12)	(-1.45)	(-1.04)	(-0.37)
2	0.014	0.018	-0.017	0.104
	(0.34)	(0.34)	(-0.20)	(0.98)
3 (Overweighted)	-0.023	0.057	0.107*	0.098
	(-0.69)	(1.52)	(1.77)	(0.78)
1 − 3	0.061	-0.103**	-0.188**	-0.153*
	(1.27)	(-2.09)	(-1.98)	(-1.70)

This table reports equal-weighted portfolio DGTW-adjusted buy-and-hold abnormal returns. In each nonattainment designation quarter, we first identify top ozone emitting firms as those with an *Ozone ratio* value (defined as the ozone air emissions for a given plant as a proportion of the plant's overall air emissions averaged across all plants owned by a given firm) above the median. Independently, in each nonattainment designation quarter, we identify highly regulated (least regulated) firms as those with a *NA ratio* value (defined to be equal to the number of polluting plants located in nonattainment counties for a given firm divided by the total number of plants owned by the firm) above (below) the median. In Panel A (Panel B), we sort top ozone emitting firms that are highly regulated (least regulated) into tercile portfolios based on the average change in stock weight across all funds that hold the stock during the two quarters after the nonattainment designation relative to the two quarters before. We then compute equal-weighted DGTW-adjusted buy-and-hold abnormal returns for each portfolio for one year before the event quarter (Year−1), one year after the event quarter (Year+1), two years after the event quarter (Year+2), and three years after the event quarter (Year+3). Tercile portfolio 1 is the most underweighted portfolio, whereas tercile portfolio 3 is the most overweighted portfolio. Portfolio 1 − 3 represents a zero-investment long-short portfolio that is long tercile 1 and short tercile 3. Panel C shows the difference in returns between panels A and B. Standard errors are computed based on Newey-West correction with a lag length of 3; t-statistics are reported in the parenthesis. *, **, and *** indicate significance at the 10%, 5%, and 1% level, respectively.

Table IA.18

Underweighting and regulatory compliance costs of low ozone emitting firms around nonattainment designations.

	Pollution abatement		Regulatory enforcement				
Dep. variable:	SR activity	Total SR	High priority violation	Title V inspection	Stack test	Fail stack test	Compliance evaluation
	(1)	(2)	(3)	(4)	(5)	(6)	(7)
NA ratio$_t$	0.014	-3.146	0.119	0.311	0.363	-0.014	0.479*
	(0.14)	(-1.18)	(1.12)	(1.08)	(1.15)	(-0.29)	(1.76)
Underweight$_t$	0.034	1.904	0.002	0.096	0.560*	0.068	0.203
	(0.42)	(1.25)	(0.04)	(0.45)	(1.85)	(1.21)	(0.91)
Post NA$_t$	-0.070**	-0.643**	-0.042***	0.267***	0.125***	0.010	0.142***
	(-2.42)	(-2.18)	(-2.65)	(5.65)	(2.89)	(0.75)	(4.27)
NA ratio$_t$ × *Underweight*$_t$	-0.398	-9.475**	0.128	0.467	0.426	0.018	-0.017
	(-1.63)	(-2.36)	(0.90)	(0.87)	(0.82)	(0.19)	(-0.03)
NA ratio$_t$ × *Post NA*$_t$	0.170***	1.273**	0.066**	-0.183***	-0.065	-0.018	-0.109**
	(3.26)	(2.52)	(2.36)	(-2.63)	(-0.85)	(-0.94)	(-2.01)
Underweight$_t$ × *Post NA*$_t$	0.018	0.193	0.061	-0.235***	-0.116**	0.010	-0.132**
	(0.22)	(0.22)	(1.61)	(-3.23)	(-2.01)	(0.24)	(-2.34)
NA ratio$_t$ × *Underweight*$_t$ × *Post NA*$_t$	0.001	1.133	-0.084	0.184**	0.065	-0.012	0.140
	(0.01)	(0.76)	(-1.61)	(2.04)	(0.68)	(-0.19)	(1.10)
Stock controls	Yes	Yes	Yes	Yes	Yes	Yes	Yes
Stock F.E.	Yes	Yes	Yes	Yes	Yes	Yes	Yes
Industry F.E.	Yes	Yes	Yes	Yes	Yes	Yes	Yes
Year F.E.	Yes	Yes	Yes	Yes	Yes	Yes	Yes
Observations	2,970	2,970	2,970	2,970	2,970	2,970	2,970
Adj R^2	0.03	0.04	0.31	0.65	0.57	0.15	0.69

This table reports the regression estimates from Equation (6) at the firm-year level for low ozone emitting firms. We focus on five years before to five years after the nonattainment designation. The dependent variable in column (1) is a dummy variable equal to one if a given firm undertakes source reduction activities related to ozone at plants located in nonattainment counties; in column (2) is the natural logarithm of one plus the amount of ozone air emissions that undergo source reduction of a given firm across all of its plants located in nonattainment counties; in column (3) is the natural logarithm of one plus the number of high priority violations of a given firm across all of its plants located in nonattainment counties; in column (4) is the natural logarithm of one plus the number of Title V inspections of a given firm across all of its plants located in nonattainment counties; in column (5) is the natural logarithm of one plus the number of stack tests of a given firm across all of its plants located in nonattainment counties; in column (6) is a dummy variable equal to one if a given firm operates a plant located in a nonattainment county that failed a stack test; and in column (7) is the natural logarithm of one plus the number of full compliance evaluations of a given firm across all of its plants located in nonattainment counties. In each nonattainment designation quarter, we identify low ozone emitting firms as those with an *Ozone ratio* value (defined as the ozone air emissions for a given plant as a proportion of the plant's overall air emissions averaged across all plants owned by a given firm) below the median. Then we sort low ozone emitting firms into terciles based on the average change in stock weight across all funds that hold the stock during the two quarters after the nonattainment designation relative to the two quarters before. *Underweight* is a dummy variable equal to one if a firm is in the lowest tercile. *NA ratio* equals to the number of polluting plants located in nonattainment counties for a given firm divided by the total number of plants owned by the firm. *Post NA* is a dummy variable equal to one for the nonattainment designation year and the five following years. For all specifications, standard errors are robust to heteroskedasticity and clustered at the firm-level; t-statistics are reported in the parenthesis. *, **, and *** indicate significance at the 10%, 5%, and 1% level, respectively. Variable definitions are presented in Table A.1 in Appendix A.

Table IA.19

Underweighting, emissions, and penalties of top ozone emitting firms around nonattainment designations.

Dep. variable:	Ozone emissions	Admin. actions	Judicial actions	Federal penalties	Local penalties	SEP costs	Compliance costs
	(1)	(2)	(3)	(4)	(5)	(6)	(7)
NA ratio$_t$	0.128	-0.037	-0.046	-0.825*	-0.401	-0.243	-0.685
	(0.06)	(-0.86)	(-1.42)	(-1.73)	(-0.99)	(-0.47)	(-1.14)
Underweight$_t$	-0.144	-0.068	-0.046	-0.914	-0.652**	-0.363	-0.886
	(-0.11)	(-0.84)	(-0.78)	(-0.97)	(-2.54)	(-1.39)	(-1.53)
Post NA$_t$	-0.989***	-0.009	0.000	-0.147	-0.076	-0.129	0.044
	(-3.15)	(-1.08)	(0.04)	(-1.19)	(-1.15)	(-1.60)	(0.49)
NA ratio$_t$ × *Underweight*$_t$	-1.802	0.183	0.073	1.911	1.858**	1.985***	3.257**
	(-0.35)	(0.95)	(0.60)	(0.91)	(2.44)	(2.81)	(2.35)
NA ratio$_t$ × *Post NA*$_t$	-0.576	0.028**	-0.001	0.320*	0.060	0.149	0.039
	(-0.92)	(2.05)	(-0.16)	(1.85)	(0.91)	(1.51)	(0.37)
Underweight$_t$ × *Post NA*$_t$	-0.187	0.011	-0.013	0.079	-0.055	0.124	-0.155
	(-0.31)	(0.58)	(-0.54)	(0.25)	(-0.41)	(0.56)	(-0.50)
NA ratio$_t$ × *Underweight*$_t$ × *Post NA*$_t$	0.946	-0.025	0.033	-0.165	0.239	-0.062	0.339
	(0.80)	(-0.81)	(0.75)	(-0.33)	(0.86)	(-0.16)	(0.62)
Stock controls	Yes	Yes	Yes	Yes	Yes	Yes	Yes
Stock F.E.	Yes	Yes	Yes	Yes	Yes	Yes	Yes
Industry F.E.	Yes	Yes	Yes	Yes	Yes	Yes	Yes
Year F.E.	Yes	Yes	Yes	Yes	Yes	Yes	Yes
Observations	3,122	3,122	3,122	3,122	3,122	3,122	3,122
Adj R^2	0.72	0.07	0.08	0.13	0.02	0.07	0.09

This table reports the regression estimates from Equation (6) at the firm-year level for top ozone emitting firms with dependent variables measuring emissions and penalties. We focus on five years before to five years after the nonattainment designation. The dependent variable in column (1) is the natural logarithm of one plus the total amount of ozone air emissions of a given firm across all plants located in nonattainment counties. The dependent variables in columns (2) and (3) are the natural logarithm of one plus the number of formal administrative and judicial actions, respectively, taken against a given firm for plants located in nonattainment counties. The dependent variables in columns (4), (5), (6), and (7) are the natural logarithm of one plus the dollar amount of federal penalties, local penalties, supplemental environmental project costs, and compliance costs, respectively, of a given firm for plants located in nonattainment counties. In each nonattainment designation quarter, we identify top ozone emitting firms as those with an *Ozone ratio* value (defined as the ozone air emissions for a given plant as a proportion of the plant's overall air emissions averaged across all plants owned by a given firm) above the median. Then we sort top ozone emitting firms into terciles based on the average change in stock weight across all funds that hold the stock during the two quarters after the nonattainment designation relative to the two quarters before. *Underweight* is a dummy variable equal to one if a firm is in the lowest tercile. *NA ratio* equals to the number of polluting plants located in nonattainment counties for a given firm divided by the total number of plants owned by the firm. *Post NA* is a dummy variable equal to one for the nonattainment designation year and the five following years. For all specifications, standard errors are robust to heteroskedasticity and clustered at the firm-level; t-statistics are reported in the parenthesis. *, **, and *** indicate significance at the 10%, 5%, and 1% level, respectively. Variable definitions are presented in Table A.1 in Appendix A.