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

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Abstract

This paper examines how mutual funds' portfolio holdings respond to environmental regulations. Using county-level ozone nonattainment status as a source of exogenous variation in environmental regulation, we find that funds underweight heavy ozone-polluting stocks exposed to nonattainment designations, which is further reinforced when there is an increase in regulation intensity. An ease in regulation due to attainment redesignations leads to an overweighting of such stocks. Our results are consistent with funds hedging against environmental regulatory risks, based on expected changes in firm fundamentals due to regulatory costs, by underweighting (overweighting) those polluting stocks whose performance covaries negatively (positively) with the regulatory shock. 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, with no signs of return reversals, and are subject to more regulatory enforcement. Such underweighting translates into better fund portfolio performance.

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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 is less work that explores how the interplay between environmental regulations and firm pollution impact on investors' rational investment decisions. We fill this gap by examining how mutual funds' portfolio holdings of polluting firms respond to environmental regulations.

This paper employs 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 in nonattainment, while those with pollution levels below the threshold are considered in attainment. Firms that operate polluting plants located in nonattainment counties face stringent regulations and mandatory pollution abatement requirements 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 to study how mutual funds adjust their holdings of polluting firms affected by nonattainment designations.

How might mutual fund portfolios respond to nonattainment designations? The "salience hypothesis" is the prevailing explanation put forth in the existing literature. Specifically, fund managers' local exposure to environmental risks amplifies the salience of these risks and results in managers overestimating the impact of these risks on firms, which leads to the underweighting of stocks exposed to these risks. For example, studies have shown that environmental risks, such as natural disasters and air pollution, that occur in close proximity to funds' headquarters lead to the underweighting of stocks affected by such risks (Alok, Kumar, & Wermers, 2020; Foroughi, Marcus, & Nguyen, 2021; Huynh, Li, & Xia, 2021).

In our setting, the salience hypothesis implies that fund managers with a local exposure to ozone-polluting firms affected by nonattainment designations may overestimate the costs of nonattainment regulations on these firms, and consequently, underweight such stocks in their portfolio holdings.

In this study, however, we offer a different explanation in that mutual funds adjust their portfolio holdings in a rational manner to hedge against nonattainment regulatory risk (Pástor, Stambaugh, & Taylor, 2021). The idea 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 (e.g., riskier operating cash flows). Funds then optimally adjust their portfolio holdings depending on how the returns 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". While the rational hypothesis also predicts underweighting of ozone-polluting firms exposed to nonattainment designations, the underlying economic mechanism of the rational hypothesis is inherently different from that of the salience hypothesis. Specifically, the underweighting of ozone-polluting firms exposed to nonattainment designations is not limited to a certain geographic vicinity of the fund's headquarters and such firms, but rather, depends on the degree to which the firm is negatively impacted by the nonattainment regulations.

Our unique setting that exploits local variation in regulatory stringency allows us to precisely identify which stocks experience additional regulatory costs, because 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. The existing literature shows that heavy ozone-polluting firms that operate multiple plants in nonattainment counties are most negatively affected by nonattainment designations since these firms are subject to increased compliance and operating costs (Becker, 2005; Becker & Henderson, 2000, 2001), which lead to lower stock price valuations (Choi, Levine, Park, & Xu, 2022; Hsu, Li, & Tsou, 2021). Thus, under the rational hypothesis, we predict that funds hedge against nonattainment regulatory risk by underweighting heavy ozone-polluting firms that operate the majority of their plants in nonattainment counties.

To empirically test the rational hypothesis, we examine changes in portfolio weights of ozone-polluting firms exposed to nonattainment designations in a triple 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. Our main finding is that funds reduce portfolio weights of heavy ozone-polluting stocks that are also heavily regulated under nonattainment designations. In economic terms, this underweighting effect translates into roughly a 1.40% drop in the dollar value of holdings for such stocks.

Our main result is 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 held, 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. In additional tests, we investigate the possibility that the underweighting of ozone-polluting firms during nonattainment designations may be driven by a particular characteristic of a mutual fund. We find, however, that the underweighting effect is prevalent regardless of a fund's distance to the nearest polluting plant, age, investment horizon, size, and concentration of stock holdings.

Our analysis also allows for the fact that attentive fund managers may be able to anticipate a county's nonattainment status, since the monitored pollution levels used to determine nonattainment status are observable. Specifically, we decompose changes in portfolio weights in response to nonattainment designations into an unexpected and anticipated component, depending on whether managers' predictions of nonattainment status are in line or opposite 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 more costs during nonattainment designations, and hence, lead to more underweighting than the average effect. In particular, we argue that the regulatory costs of nonattainment are greater for firms that do not own an ozone operating permit, operate plants that are located close to nonattainment monitors, have a low environment score, operate young plants, and have a high risk of distress, which are all shown to lead to worse stock price valuations during nonattainment designations (Choi et al., 2022). Consequently, we find that heavy ozone-polluting firms with the aforementioned characteristics are underweighted more in fund portfolios' hedging adjustments to nonattainment regulatory shocks.

In the next set of analysis, we study portfolio responses to two related types of regulatory shocks, including 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 face even greater regulatory costs, which further negatively impact on their stock price valuations (Choi et al., 2022), the rational hypothesis predicts an underweighting of these stocks by mutual funds. Using a similar triple difference-in-differences setting, we find that funds underweight heavy ozone-polluting firms exposed to bump-ups and confirm the absence of pre-trends. However, when we decompose portfolio responses to bump-ups into an unexpected and anticipated component, we find that both components are driving the underweighting effect. This result is consistent with the fact that there is more uncertainty surrounding both the timing and accuracy in predicting bump-ups when compared to nonattainment designations. As a result, even if fund managers can anticipate in advance the bump-up of a county, they may not hedge against such a regulatory shock until the effective date of the bump-up.

Redesignations to attainment, on the other hand, occur when a county has attained the NAAQS and represent an easing of regulation. Attainment redesignations favor those heavy ozone-polluting firms operating plants in existing nonattainment counties due to a reduction in compliance costs if they decide to expand operations, leading to an increase in their stock price valuations (Choi et al., 2022; 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 characteristics that are associated with a greater underweighting effect during nonattainment designations now lead to a greater overweighting effect.

The salience and rational hypotheses also have different predictions for 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 as compared to less-affected firms. We also evaluate the abnormal stock returns of the most underweighted heavy ozone-polluting stocks that are highly regulated under nonattainment regulations in the post-nonattainment period. If the underweighting effect 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 under nonattainment regulations, we find that the most underweighted 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 argue that if the underweighted top ozone-polluting firms are those that funds expect to be most negatively impacted by nonattainment designations, then we would expect these firms to be subject to more regulatory compliance costs in the post-nonattainment period. Using a facility's observable regulatory enforcement and pollution abatement efforts as proxies for potential compliance costs, we confirm that the regulatory enforcement activities and pollution abatement investments 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. The research in this area has so far mainly focused on salience-related theories that explain changes in portfolio weights based on the proximity of a fund's location and environmental risks, which result in biased decision making by fund managers (Alok et al., 2020; Foroughi et al., 2021; Huynh et al., 2021). Salience bias due to local exposure to environmental risks has also been used to explain the portfolio choice decisions of individual investors (e.g., Bharath & Cho, 2022; Choi, Gao, & Jiang, 2020; Li, Massa, Zhang, & Zhang, 2021). While some studies do take a rational approach to explain changes in portfolio holdings in response to environmental risks, their focus is different from ours since they either focus on the risky asset holdings of individual investors (Gao, Jo, & Lam, 2022) or mutual fund bond holdings (Cao, Li, Zhan, Zhang, & Zhou, 2022). In this paper, we argue that funds hedge against environmental *regulatory* risks by underweighting heavy ozone-polluting firms exposed to nonattainment designations because these firms bear additional costs that negatively impact on their firm fundamentals.

Our study also contributes to the literature that examines the environmental determinants of institutional investors' stock holdings. Existing studies have shown that institutional investors' portfolio choices depend on competition for climate-conscious investment flows (Ceccarelli, Ramelli, & Wagner, 2021), firms' environmental, social, and governance (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 also 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 et al., 2022; Monasterolo & de Angelis, 2020), and mandatory carbon disclosure law (Jouvenot & Krueger, 2021). However, the difference between these studies and ours is that global climate policies are less binding and harder to enforce than local environmental regulations.[1] 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 real 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. Prior studies have used nonattainment designations to study the effect of environmental regulations on health outcomes (Bishop,

[1] See, for example, `https://www.nytimes.com/2017/05/09/climate/paris-climate-agreement-kyoto-protocol.html`.

Ketcham, & Kuminoff, 2020), industrial activity (Becker & Henderson, 2000; Greenstone, 2002; List, McHone, & Millimet, 2004; List, Millimet, Fredriksson, & McHone, 2003), housing prices (Bento, Freedman, & Lang, 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, 2018; Greenstone, 2003). To our knowledge, we provide the first empirical analysis that uses nonattainment designations to show that environmental regulations have a material impact on the allocation of capital of polluting firms in the financial markets.

2. Background on pollution and environmental regulations

In the United States, air pollution is regulated under the CAA, the largest environmental program in the country. The act was passed in 1963 and subsequently amended in 1970, 1977, and 1990. The 1970 Clean Air Act Amendments (CAAA) established the EPA, which is authorized to implement and regulate separate federal air quality standards, formally known as the NAAQS, for six criteria air pollutants (carbon monoxide, nitrogen dioxide, ozone, sulfur dioxide, particulate matter, and lead). The NAAQS place pollutant-specific limits on the maximum allowable concentration of pollution in a given area to provide protection of human health. In this paper, we focus only on ozone since the largest benefits from the CAA are derived from ozone (Muller, Mendelsohn, & Nordhaus, 2011), the majority of counties are in nonattainment under the ozone NAAQS, and the standards for ozone have been the most difficult for counties to meet (Curtis, 2020).

The 1977 CAAA specified that every county in the United States must be designated annually as being in attainment or out of attainment (nonattainment) with respect to the NAAQS. For counties that are designated nonattainment, the EPA requires each state to submit state implementation plans (SIP), which are comprehensive plans that outline how a state will bring their counties back into compliance (United States Environmental Protection Agency, 2013). Failure to submit and execute an acceptable SIP can potentially result in federal sanctions, including the withholding of federal grant monies (e.g., highway construction funds), direct EPA enforcement and control (through federal implementation plans), penalty fees, and construction bans on new polluting establishments (Becker & Henderson, 2000; Greenstone, 2002).

Environmental regulations in nonattainment counties are intended to be stringent. These regulations demand that substantial investments, either by new or existing plants, be accompanied by 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. These emission limits impose significant compliance costs on ozone-polluting firms operating in nonattainment counties (Becker & Henderson, 2001).

For a county to be redesignated as attainment, states must develop proper SIPs demonstrating the regulatory actions that will be taken to meet and maintain the NAAQS. In attainment counties, polluting plants face a more lax regulatory standard. Installation of new pollution abatement technology is accompanied with a consideration on the economic burden on the polluting plant before arriving at a final solution. Large-scale investments involve less expensive pollution abatement equipment and emission offsets are not necessary. Finally, since the NAAQS only apply to plants that emit a given criteria air pollutant, nonpolluters are free from regulation no matter the county's designation status.

The 1990 CAAA introduced a classification system for ozone which ranks the severity of a county's nonattainment status from marginal to extreme. Nonattainment counties for ozone with a more severe classification are given more time to meet the NAAQS, but face greater regulatory stringency. The EPA has authority to bump up nonattainment counties from a lower classification to a higher one ("bump-up classifications") if the state fails to demonstrate attainment by the given date as specified in the SIP.

In this study, we use nonattainment designations as exogenous shocks to local regulatory stringency. All counties are evaluated on the same NAAQS standards, so nonattainment designations are likely to be exogenous to all county-specific characteristics other than local air quality conditions. Additionally, studies show that nonattainment designations often depend on weather patterns (Cleveland & Graedel, 1979; Cleveland, Kleiner, McRae, & Warner, 1976), suggesting that nonattainment status is unlikely to be related to differences in tastes, geographic attributes, or underlying economic conditions across counties. Finally, nonattainment regulations are generally free from county-wide influences such as local firms' collective lobbying power and the county's political environment, since the EPA's enforcement power limits the states' ability to overlook non-compliers.

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. Our sample focuses on domestic actively managed equity mutual funds.[2] 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.

Each quarter, we calculate the weight (percentage) 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. To avoid multiple counting of funds that have more than one share class, we aggregate these classes into a single fund. In particular, we compute fund size, *ln(Fund size)*, as the natural logarithm of one plus the sum of total net assets (TNA) of all fund classes. A fund's quarterly return, *Fund returns*, is calculated as the weighted average of returns over the share classes, using individual share classes' total net assets as the weight. Similarly, we also compute weighted average expense ratios (*Expense ratio*) and turnover ratios (*Turnover ratio*). Lastly, we compute fund flow in quarter t, *Net flow*, as $100 \times (TNA_t - (1 + \textit{Fund returns}_t) \times TNA_{t-1}) / TNA_{t-1}$.

3.2. Firms' ozone pollution and control variables

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, 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

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

as the plant's name, county of location, industry, and parent company's name. 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; United States Environmental Protection Agency, 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 (2018) and exclude the period 1987 to 1990 from our analysis. 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.[3] 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.[4] Although the TRI data provides information on chemical emissions through the ground, air and water, we only consider emissions through the air 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 1,012 unique firms from 1991 to 2019.

We control for a set of firm characteristics that are potential determinants of fund holdings. In particular, we 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

[3]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.

[4]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.

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*).

3.3. 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 search the Federal Register and hand-collect the effective dates of every event. To ensure that there are no spillover effects between events of different types, we remove any event that occurs within two weeks of another type of event centered on the event date. 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.[5] 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 1,632 nonattainment designation event-quarters concerning 828 firms, 864 bump-up event-quarters concerning 349 firms, and 1,398 attainment redesignation event-quarters concerning 461 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 statistics that the EPA uses to determine whether a county is in compliance with the NAAQS each year. Essentially, counties with DVs that are above the relevant threshold are likely to be designated nonattainment, while those below the threshold are likely to remain in attainment.[6] 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

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

[6] Although DVs are one component that the EPA uses to determine nonattainment status, they are not the only contributing factor. The EPA uses a five-factor approach in evaluating a county's designation status and each county's circumstances are considered on a case-by-case basis. See `https://www.epa.gov/ozone-designations/ozone-designations-guidance-and-data#B` for more details.

information publicly available to fund managers at the time of nonattainment designations.[7] Thus, we tailor the calculation of the DVs using time periods that mimic, as close as possible, the information available to fund managers at the time of nonattainment designations.

3.5. Construction of key variables

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 (in pounds) for a given plant as a proportion of the plant's overall air emissions (in pounds), averaged across all plants owned by a given firm. This variable is also constrained between zero and one, and a higher value indicates a greater proportion of the firm's pollution is ozone.

Bump-up classifications are conditional on nonattainment status. Thus, to measure a firm's exposure to bump-ups, we compute 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. 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 polluting plants owned by the firm.

Since a county's monitored ozone pollution levels are observable, attentive fund managers may be able to anticipate a county's nonattainment status. We exploit this feature of our setting and decompose nonattainment designations into an anticipated component and an unexpected component, based on county-level DVs. Specifically, we calculate the DVs of each county for each ozone standard and determine whether the county is in nonattainment, based on whether the DVs exceed the relevant threshold.[8] We define unexpected nonattainment

[7]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.

[8]We compute DVs using only the data available to fund managers at the time of nonattainment designations. For example, the rule used to calculate the DVs for the 1997 ozone standard is the three-year rolling average of the fourth highest daily ozone reading in each year. Thus, we use ozone concentration data from 2001 to 2003 in calculating DVs to predict a county's nonattainment status for the actual designation date on June 15, 2004.

designations as those counties that are predicted to be in attainment based on DVs, but end up in nonattainment on the actual designation date. Similarly, anticipated nonattainment designations refer to those counties that are predicted to be nonattainment based on DVs and do actually end up in nonattainment. 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 by the firm, respectively.

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 located in a nonattainment county. In addition, approximately 10.5% of a firm's polluting plants are exposed to unexpected nonattainment designations, while 23.5% 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 8.3% of a firm's polluting plants are affected.

Table 1 reports county-level characteristics by state. Connecticut has the highest number of TRI parent firms per county, followed by Massachusetts. These two states also have the highest number of TRI ozone and non-ozone plants per county. Pennsylvania and California have the two highest number of nonattainment counties. 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.

4. Hypotheses and empirical strategy

In this section, we outline the main theories that have implications for how mutual funds adjust their portfolio holdings of polluting stocks that are affected by nonattainment designations. Then, we develop testable hypotheses and discuss our empirical methodology.

4.1. Hypothesis development

The literature that studies changes in mutual fund portfolio holdings in response to environmental risks has so far attributed the underweighting of affected stocks to salience bias (i.e., salience hypothesis). The idea is that fund managers are subject to "local thinking", whereby they make biased decisions based on the ease with which events can be recalled. For example, fund managers that have experienced natural disasters overestimate the probability of such disasters occurring in the future and underweight stocks exposed to such climatic events in their portfolios (Alok et al., 2020). Similarly, fund managers overestimate carbon risk when they are exposed to local air pollution and underweight firms with high carbon emissions (Huynh et al., 2021). Exposure to local air pollution is also shown to influence managers' personal preference on environmental issues, which results in the underweighting of firms with low environmental ratings (Foroughi et al., 2021).

Salience bias is also documented at the individual investor level and is shown to lead to the underweighting of affected stocks through investors' local exposure to abnormal temperatures (Choi et al., 2020), air pollution (Li et al., 2021), and natural disasters (Bharath & Cho, 2022). The crux of the salience hypothesis stems from a fund manager's or an individual's local exposure to environmental events. In the aforementioned studies, local exposure is measured by restricting the fund's headquarters or individual's residence to be within a certain geographical distance of the air pollution, natural disaster, or abnormal temperature. Thus, applying the salience hypothesis in our setting implies that fund managers located in close proximity of ozone-polluting firms that are affected by nonattainment designations may overestimate the costs of regulations on these firms, and, consequently, underweight such stocks in their portfolios.

We posit, however, that if mutual funds are responding to nonattainment designations in a rational manner (i.e., rational hypothesis), then the underweighting of polluting firms exposed to nonattainment designations should be independent of the geographic vicinity of the fund and such firms, but rather, be driven by an economic mechanism that is optimal for the fund.

The underlying mechanism of the rational hypothesis is best illustrated using the theoretical model developed by Pástor et al. (2021). Applying their model in our setting implies that a fund's optimal portfolio holdings in equilibrium are determined by stocks' financial payoffs, ESG characteristics (e.g., pollution), and exposure to environmental regulatory risks (e.g., nonattainment designations). Whether a stock is underweighted or overweighted is ultimately an empirical question that depends on how well it can hedge against the regulatory risks, which in turn depends on how the returns 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.

Although nonattainment designations imply that there is an overall increase in regulatory stringency, not all firms are regulated uniformly during nonattainment designations. For example, a firm that operates many ozone plants, but are all located in attainment counties, is unaffected by the costs of nonattainment regulations. Likewise, a firm that operates many plants in nonattainment counties, but none of the plants emit ozone, is also unaffected. The existing literature shows that multi-plant firms in nonattainment areas are regulated the most intensely and generally targeted first by regulators (Becker & Henderson, 2000). These firms are shown to face higher production costs in nonattainment areas relative to their less-regulated counterparts in attainment areas (Becker & Henderson, 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.

Increases in environmental regulatory costs have been shown to negatively impact on firm fundamentals, leading to lower stock price valuations and profitability (Bolton & Kacperczyk, 2021; Hsu et al., 2021; Jouvenot & Krueger, 2021). In particular, Choi et al. (2022) show that the additional compliance costs from nonattainment regulations negatively impact on the stock returns of heavy ozone-polluting firms exposed to nonattainment designations. Thus, under the rational hypothesis, mutual funds are predicted to underweight heavy ozone-polluting firms that operate most of their plants in nonattainment counties, since the stock returns of these firms covary negatively with the nonattainment regulatory shock.

Besides the different economic mechanisms driving the underweighting of affected stocks, the salience hypothesis and rational hypothesis also have different implications for the future performance of the underweighted stocks and associated fund portfolio performance. Specifically, the salience hypothesis is based on fund managers' overreaction to the costs of nonattainment designations on ozone-polluting firms, while the rational hypothesis is based on expected changes in firm fundamentals due to the costs of nonattainment regulation (e.g., operating cash flows are more risky for ozone-polluting firms operating in nonattainment counties). Thus, under the rational hypothesis, we expect a drop in the operating performance of heavy ozone-polluting firms in the post-nonattainment period. Similarly, if the underweighting of heavy ozone-polluting firms is a rational decision, then we expect the most underweighted firms to exhibit worse abnormal return performance in the post-nonattainment period. On the other hand, if the underweighting is due to salience bias, then we should observe significant return reversals in the post-nonattainment period. Finally, under the rational hypothesis, the underweighting of heavy ozone-polluting firms is driven by fund portfolios' hedging adjustments to regulatory risks. Thus, we predict that the funds that engage in the most underweighting experience superior portfolio performance in the post-nonattainment period.

4.2. Empirical methodology

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 triple 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.[9]

We then simplify our triple difference-in-differences specification to a double difference specification by taking the (post minus pre) change in portfolio weights as the outcome variable. The unit of observation in our analysis is a fund-firm-event quarter. Formally, our baseline

[9]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.

specification is as follows:

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

for fund m, stock s, and quarter t. Note that unlike the studies on the salience hypothesis, we do not restrict the fund's headquarters to be within a certain geographic vicinity of a polluting firm exposed to nonattainment designations. Rather, our specification is motivated by Pástor et al.'s (2021) model, whereby we examine how a fund adjusts its portfolio holdings to hedge against nonattainment regulations, based on a stock's: i) dependence on ozone emissions (*Ozone ratio*); and ii) exposure to nonattainment designations (*NA ratio*).

The dependent variable, $\Delta w_{m,s}$, is the change in the average weights (in percentage) 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 of quarter $t-1$. Following Kang and Stulz (1997), control variables for firm characteristics include *ln(Size)*, *ln(BM)*, *ROA*, *Leverage*, *Sales growth*, *Momentum*, and *Stock returns*. Following Alok et al. (2020), control variables for fund characteristics include *Expense ratio*, *Turnover ratio*, *ln(Fund size)*, *Net flow*, and *Fund returns*.

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 underweight heavy ozone-polluting firms that are overly exposed to nonattainment designations. 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.

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 performance of these firms covaries negatively with 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* $\times$ *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 effect, 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.[10] The coefficient estimate on the triple interaction term *NA ratio* $\times$ *Ozone ratio* $\times$ *Post NA* is -0.049% (unreported) and statistically significant. While this coefficient's magnitude may seem somewhat small, for a typical fund in our sample, this translates into a sizable 1.40% drop in dollar value for stocks with an above median *NA ratio* and *Ozone ratio* value.[11]

Next, we utilize more stringent fixed effects. Column (5) of Table 3 uses fund $\times$ stock fixed effects, column (6) uses fund $\times$ year-quarter fixed effects, and column (7) includes both sets of fixed effects.[12] Across all three columns, the coefficients on *NA ratio* $\times$ *Ozone ratio* remain negative and statistically significant. These results indicate that our main findings continue to

[10]The dependent variable in this analysis is the weight in levels and not the difference.

[11]The median size of a mutual fund portfolio in the nonattainment designations sample is \$176.38 million. The dollar value invested by funds in stocks with an above median *NA ratio* and *Ozone ratio* value is \$1.5 million. In this subset of stocks, the median *NA ratio* and *Ozone ratio* values are 0.44 and 0.54, respectively. So, a reduction in overall portfolio weight of 0.049% after the nonattainment designation translates into $0.049\% \cdot 0.44 \cdot 0.54 \cdot 176.38/1.5 \approx 1.40\%$ reduction in the dollar value of a stock holding.

[12]In columns (6) and (7), the fund control variables are absorbed by the fund $\times$ year-quarter fixed effects.

hold after controlling for unobservable, time-varying fund characteristics and differences in fund managers' preferences to hold ozone-polluting stocks.

It is interesting to note that the coefficients on *NA ratio* and *Ozone ratio* in Table 3 are all positive and statistically significant, which is also in line with the predictions of the rational hypothesis. 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. The aforementioned 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*. Our focus is on the four quarters prior to four quarters after a nonattainment designation. The quarter before the nonattainment designation is the omitted category.

Figure 1 reports the point estimates (solid line) and 95% confidence intervals (dashed lines) of the coefficients for the interaction terms *NA ratio* $\times$ *Ozone ratio* $\times$ *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 underweighting effect. This observation is consistent with the interpretation that the covariance between the stock returns of ozone-polluting firms and the nonattainment regulatory shock is most negative during the three quarters post event, where the market is still slowly 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 underweighting effect.

5.1.3. 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) uses differences in portfolio weights and 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 Table 4. Across all specifications of fixed effects, the coefficients on *NA ratio* $\times$ *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. In particular, during nonattainment designations, the probability of a stock with a median value of *NA ratio* and *Ozone ratio* being underweighted increases by 0.1% ($= 0.243 \cdot 0.272 \cdot 0.015$), corresponding to an increase of 2.33% 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) during the post-nonattainment designation quarters relative to the pre-nonattainment designation quarters; and Δ*Traded value*, defined as the change in 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 Table 5 present the results using Δ*Shares* as the dependent variable, while columns (3) and (4) use Δ*Traded value*. Across all columns, we find that the coefficients on *NA ratio* $\times$ *Ozone ratio* are negative and statistically significant, indicating that funds tend to sell more shares of heavy ozone-polluting firms exposed to nonattainment regulations. Overall, the results in this section suggest that our main findings are not simply driven by temporary share price drops of polluting firms.

5.1.4. Fund characteristics and changes in portfolio weights

In this section, we examine the possibility that the underweighting of ozone-polluting firms during nonattainment designations may be driven by a particular characteristic of a mutual fund. Specifically, we examine whether the underweighting effect is influenced by a fund's distance to the nearest polluting plant, age, investment horizon, size, and concentration of stock holdings.

The first fund characteristic that we study is the distance between a fund's headquarters and the closest polluting plant of a given firm. If the salience hypothesis is driving our results, then we expect to observe the underweighting of heavy ozone-polluting stocks only in the sample of funds that are located "close" to the polluting plants, while those located "far" away should not adjust their portfolio holdings in response to nonattainment designations. As for the other fund characteristics, it could be possible that younger funds misestimate the impact of nonattainment designations on a firm's stock price and disproportionately sell ozone-polluting stocks (Chevalier & Ellison, 1997). Thus, if only young funds exhibit underweighting during nonattainment designations, then this may cast doubt on the economic mechanism underlying the rational hypothesis.

Similarly, funds with longer investment horizons tend to prefer firms with higher ESG profiles (Starks et al., 2020). To the extent that ozone-polluting firms may have lower ESG profiles, nonattainment designations may enable funds with a long-term horizon to reevaluate the ESG profiles of their holdings and underweight ozone-polluting firms. Small funds are likely to be overinvested in local stocks, resulting in excessively risky portfolios (Pool, Stoffman, & Yonker, 2012). Thus, small funds may have a greater incentive to hedge against nonattainment regulatory shocks, which results in the underweighting of ozone-polluting stocks. Finally, it is possible that underdiversified funds may be particularly sensitive to temporary shocks stemming from nonattainment designations because of their higher idiosyncratic risks and find it optimal to reduce their holdings of polluting stocks (Kacperczyk, Sialm, & Zheng, 2005).

To examine these possibilities, we divide our sample by fund characteristics with above and below median values of each fund characteristic, and estimate Equation (1) in the two subsamples. Table 6 presents the results. We measure fund age as the number of years a given fund has been in existence since its inception. We calculate a fund's churn ratio following Gaspar, Massa, and Matos (2005) as a measure of its investment horizon, with higher values indicating that the fund turns over its holdings faster. We use two measures for fund 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 the first two columns, we see that funds underweight heavy ozone-polluting firms exposed to nonattainment designations, regardless of their headquarter's distance to the nearest polluting plant of the given firm. This result provides evidence against the salience hypothesis.

Across all subsamples of the remaining fund characteristics, the coefficients on *NA ratio* × *Ozone ratio* remain negative and statistically significant, indicating that the underweighting of ozone-polluting firms during nonattainment designations is not driven by any particular fund characteristic. Columns (7) and (8) of Table 6 indicate that while the underweighting effect is prevalent in both large and small funds, the effect is stronger for small funds, with a statistically significant coefficient difference on *NA ratio* × *Ozone ratio* between the two subsamples of funds. This result is consistent with small funds holding excessively risk portfolios, which lead to a greater underweighting of heavy ozone-polluting stocks to hedge against regulatory risks. Similarly, in columns (9) to (12), both concentrated and well-diversified funds exhibit signs of underweighting, but the effect is stronger for concentrated funds. This result is consistent with the interpretation that underdiversified funds have higher idiosyncratic risks and find it optimal to reduce exposure to heavy ozone-polluting firms.

5.1.5. *Changes in portfolio weights in response to unexpected and anticipated nonattainment designations*

In this section, we decompose portfolio responses of ozone-polluting firms to nonattainment designations into an unexpected and anticipated component. When there is 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 7. 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. These results indicate that funds are only underweighting those ozone-polluting stocks with plants located in counties experiencing unexpected nonattainment designations.

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 the markets' beliefs of nonattainment status are opposite to realizations, hence, these unexpected nonattainment designations reveal new information on the covariance between stock returns and the nonattainment regulatory shock, which has not yet been predicted by the market. Consequently, funds hedge against these unexpected regulatory risks by underweighting heavy ozone-polluting stocks. Anticipated nonattainment designations, on the other hand, are those where the markets' prediction of nonattainment status are in line with realizations and so there is relatively little new information on stock returns revealed from these shocks. Thus, any hedging adjustments in response to anticipated nonattainment designations should have occurred before the actual designation event.

5.1.6. Heterogeneous portfolio responses to nonattainment designations

We now explore possible heterogeneity in the changes in portfolio weights to nonattainment designations. Specifically, we examine firms with certain characteristics that will impose more costs upon them during nonattainment designations, and hence, lead to lower stock market valuations. Under the rational hypothesis, we expect funds to hedge against nonattainment regulatory shocks by underweighting such firms more than the average effect documented in Section 5.1.1. We augment Equation (1) with a variable Z that refers to a set of firm characteristics and its corresponding interactions. Our focus is on the triple interaction term *NA ratio* $\times$ *Ozone ratio* $\times$ Z that represents the differential effects of a particular firm characteristic on the underweighting of heavy ozone-polluting firms exposed to nonattainment designations.

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. During nonattainment designations, heavy ozone-polluting firms that do not own any ozone operating permits have a greater risk of violating nonattainment regulations (Walker, 2013), and hence, experience lower stock market valuations compared to those that own operating permits (Choi et al., 2022). Thus, we expect heavy ozone-polluting firms that do not own any ozone operating permits to be underweighted more by funds during nonattainment designations.

Next, we consider the average distance of a firm's plants to the closest nonattainment monitor.[13] During nonattainment designations, firms that operate ozone emitting plants located close to nonattainment monitors are regulated more intensely than those located

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

further away, since regulatory effort is localized in the areas surrounding nonattainment monitors (Auffhammer, Bento, & Lowe, 2009; Bento et al., 2015; Gibson, 2018). Thus, firms with plants that are located close to nonattainment monitors are subject to greater regulatory costs, leading to a negative impact on their stock prices (Choi et al., 2022). The underweighting effect is likely to be greater for firms operating ozone emitting plants closer to nonattainment monitors during nonattainment designations.

We then investigate a firm's environment score obtained from KLD.[14] Firms with higher environment scores are better protected from negative environmental shocks (Godfrey, Merrill, & Hansen, 2009) and implement superior corporate environmental policies that mitigate environmental risk exposure, which leads to higher valuations (Chava, 2014; Fernando et al., 2017). For example, Choi et al. (2022) show that the regulatory costs from nonattainment designations on heavy ozone-polluting firms with low environment scores results in lower stock price valuations for these firms. Consequently, we argue that firms with low environment scores exposed to nonattainment designations are underweighted more by funds.

We also examine the proportion of "young" plants that a given firm operates. Becker and Henderson (2001) find that younger plants in nonattainment counties face higher production costs because older plants can escape the stringent regulations on new equipment until they renew equipment or expand operations. Thus, nonattainment designations are more costly for heavy ozone-polluting firms that operate a large proportion of young plants, which leads to lower stock price valuations for these firms (Choi et al., 2022). As a result, we expect the underweighting effect to be greater for those firms that operate mostly young plants.

The last firm characteristic we study is a firm's risk of distress. Akey and Appel (2021) show that firms with a high risk of distress may benefit from events that reduce potential environmental costs by shifting harm to other stakeholders. Since nonattainment designations represent an *increase* in potential environmental costs, heavy ozone-polluting firms with a high risk of distress are limited in their ability to benefit from such an event, implying that these firms are likely to experience more negative stock price valuations compared to firms with a low risk of distress. For example, Choi et al. (2022) show that heavy ozone-polluting firms with a high risk of distress experience lower CARs during nonattainment designations. As a result, we expect firms with a high risk of distress to be underweighted more by funds.

We examine the aforementioned firm characteristics using the following variables: i) *No*

[14] This dataset has been used extensively in the finance literature to assess corporate environmental performance (e.g., Deng, Kang, & Low, 2013; Fernando, Sharfman, & Uysal, 2017; Sharfman & Fernando, 2008).

ozone permit, a dummy variable equal to one if a given firm does not own an ozone operating permit, and zero otherwise;[15] ii) *Close NA monitor*, 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; iii) *Low environment score*, a dummy variable equal to one if the difference between the average strength and concern environment scores for a given firm is below the median, and zero otherwise; iv) *Young plant*, a dummy variable equal to one if the average plant age of a given firm is between zero and five years, and zero otherwise (Becker & Henderson, 2001);[16] and v) *Low z-score*, a dummy variable equal to one if the Altman's unlevered z-score for a given firm is below the median, and zero otherwise.

Figure 4 presents the results. The horizontal axis shows the point estimates and the corresponding 95% confidence intervals for the triple interaction term. For each specification, the variable included in Z is listed on the vertical axis. As discussed, the firm characteristics variables are all predicted to impose additional regulatory costs on the firm, which result in worse stock price valuations during nonattainment designations. The figure shows that the coefficients on $NA\ ratio \times Ozone\ ratio \times Z$ are all negative and statistically significant (at the 5% level or better) for these firm characteristics, indicating that heavy ozone-polluting firms with these characteristics are underweighted more in fund portfolios' hedging adjustments to nonattainment regulatory shocks.

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. Choi et al. (2022) show that the increase in regulatory costs due to bump-ups for these firms further decreases their stock price valuations. Therefore, 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.

The set of counties that we examine are those that were initially designated nonattainment and then subsequently experienced a bump-up from a lower classification to a higher one. We

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

[16] 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.

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

$$\Delta w_{m,s} = \beta_0 + \beta_1 Bump\ ratio_{s,t} + \beta_2 Ozone\ ratio_{s,t-1} + \beta_3 Bump\ ratio_{s,t} \times Ozone\ ratio_{s,t-1} + X_{s,t-1} + X_{m,t-1} + \mu_m + \tau_s + \rho_t + \varepsilon_{m,s,t} \tag{2}$$

for fund m, stock s, and quarter t. The dependent variable is the change in the average weights (in percentage) 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-us are conditional on nonattainment status, *Ozone ratio* is defined as the ozone air emissions (in pounds) for a given plant as a proportion of the plant's overall air emissions (in pounds), 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 (2) in Panel A of Table 8. 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 typical fund in our sample, it corresponds to a 1.50% drop in dollar value for stocks with an above median *Bump ratio* and *Ozone ratio* value.[17] Similar to our results on nonattainment designations, we find that funds reallocate holdings toward stocks that are not affected by bump-ups. 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 2, we examine the dynamics of portfolio weights (levels) around bump-ups. Our focus is on the four quarters

[17] Reverting Equation (2) to a triple difference-in-differences specification allows an economic interpretation of the underweighting effect. Specifically, the coefficient on *Bump ratio* × *Ozone ratio* × *Post Bump* is -0.055% (unreported). The median size of a mutual fund portfolio in the bump-up classifications sample is \$148.08 million. The dollar value invested by funds in stocks with an above median *Bump ratio* and *Ozone ratio* value is \$1.6 million. In this subset of stocks, the median *Bump ratio* and *Ozone ratio* values are 0.50 and 0.58, respectively. So, a reduction in overall portfolio weight of 0.055% after the bump-up classification translates into $0.055\% \cdot 0.50 \cdot 0.58 \cdot 148.08/1.6 \approx 1.50\%$ reduction in the dollar value of a stock holding.

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 third quarter post event and dissipates by the fourth quarter.

Next, we decompose the change in portfolio weights in response to bump-ups into an unexpected and anticipated component. Nonattainment counties that do not improve their DVs to a specified level 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. We define unexpected bump-ups as those counties that are predicted to not experience bump-ups because they see an improvement in DVs, but end up receiving a bump-up on the effective date. Similarly, anticipated bump-ups are those counties that are predicted to be bumped up because they do not see an improvement in DVs and do actually end up experiencing a bump-up on the effective date. 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. Then, we replace *Bump ratio* and its corresponding interaction terms in Equation (2) with *Unexp. bump ratio* and *Antic. bump ratio*.

We present the estimation results in Panel B of Table 8. The coefficients on both *Unexp. bump ratio* $\times$ *Ozone ratio* and *Antic. NA ratio* $\times$ *Ozone ratio* are negative and statistically significant, indicating that funds underweight ozone-polluting firms that are exposed to both unexpected and anticipated bump-ups. Although this result is in contrast to the underweighting of ozone-polluting firms during nonattainment designations, whereby funds only respond to the unexpected component, it is consistent with the fact that there is more uncertainty surrounding the timing of the anticipated component of bump-ups. In particular, no improvement in DVs is not the only contributing factor to a bump-up classification. If a county cannot meet the attainment deadline in the SIP, but overall ozone pollution appears to be on a downward trend, the county can apply for an attainment date extension, which if granted by the EPA, avoids a bump-up thereby inducing uncertainty in the timing of the bump-up classification. Furthermore, it is difficult to predict the category to which the county will be bumped-up to. These reasons imply that even if fund managers can anticipate in advance the bump-up of a county, they may not hedge against such a regulatory shock until the effective date of the bump-up, since there is a degree of uncertainty in their apriori predictions.

5.3. Portfolio response to attainment redesignations

Redesignations to attainment represent an easing of regulation, which favors those heavy ozone-polluting firms due to a reduction in compliance costs if they decide to expand operations. For example, Becker (2005) finds that regulatory costs are significantly less costly to firms operating plants in attainment counties when compared to those in nonattainment counties. As a result of the decrease in regulatory stringency, heavy ozone-polluting firms operating in counties facing attainment redesignations experience an increase in their stock price valuations. Choi et al. (2022) find that heavy ozone-polluting firms exposed to nonattainment designations experience higher CARs during attainment redesignations. Ramelli et al. (2021) show that the stock market reacts positively to laxer regulation that favors carbon-intensive firms. 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 centered on the attainment redesignation quarter and estimate the following specification:

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

for fund m, stock s, and quarter t. The dependent variable is the change in the average weights (in percentage) of a given stock in a given mutual fund's portfolio during the post-attainment redesignation quarters relative to the pre-attainment redesignation quarters. $X_{s,t-1}$ 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 (3) in Panel A of Table 9. Consistent with our predictions, the coefficients on *Redesig ratio* $\times$ *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, albeit smaller in absolute value compared to that of the underweighting effect during nonattainment designations. Specifically, for the typical fund in our sample, funds respond to attainment redesignations with a 0.68% increase in the dollar value for stocks with an above median *Redesig ratio* and *Ozone ratio* value.[18] Figure 3 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 weights in the event quarter, which continues until the fourth quarter post event.

Next, we decompose portfolios' response to attainment redesignations into an unexpected and anticipated component. In nonattainment counties where monitored data demonstrate that the NAAQS has been achieved, the EPA may issue a "clean data determination", indicating that the air quality has met the required standard. Thus, attentive fund managers who observe which counties receive clean data determinations may be able to predict attainment redesignations. We define unexpected attainment redesignations as those counties that are predicted to remain in nonattainment because they 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 are predicted to be redesignated to attainment because they receive a clean data determination and do actually end up redesignated to attainment. We replace *Redesig ratio* and its corresponding interaction terms in Equation (3) 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 polluting plants owned by the firm, respectively.

Panel B of Table 9 reports the estimation results. The coefficients on *Unexp. redesig ratio* $\times$ *Ozone ratio* are positive and statistically significant, while those on *Antic. redesig ratio* $\times$ *Ozone ratio* are 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 the stock price valuations for polluting firms during anticipated attainment redesignations. Specifically, a clean data determination signals that the air quality in a county has attained the relevant standard, implying that many nonattainment regulations cease to be applicable. For firms operating polluting plants in these

[18] Reverting Equation (3) to a triple difference-in-differences specification allows an economic interpretation of the overweighting effect. Specifically, the coefficient on *Redesig ratio* $\times$ *Ozone ratio* $\times$ *Post Redesig* is 0.125% (unreported). The median size of a mutual fund portfolio in the attainment redesignation sample is \$166.96 million. The dollar value invested by funds in stocks with an above median *Redesig ratio* and *Ozone ratio* value is \$1.37 million. In this subset of stocks, the median *Redesig ratio* and *Ozone ratio* values are 0.08 and 0.53, respectively. So, an increase in overall portfolio weight of 0.125% after the attainment redesignation translates into $0.125\% \cdot 0.08 \cdot 0.53 \cdot 166.96/1.37 \approx 0.68\%$ increase in the dollar value of a stock holding.

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.

Finally, we explore possible heterogeneity in funds' adjustments of portfolio weights in response to attainment redesignations, by conducting the same analysis as in Section 5.1.6. Since attainment redesignations lead to a reversal in environmental regulatory stringency when compared to nonattainment designations, we expect the same firm characteristics to have a positive impact on stock price valuations, leading to more overweighting than the average effect. Figure 5 presents the coefficient estimates on the triple interaction term $\textit{Redesig ratio} \times \textit{Ozone ratio} \times Z$. With the exception of a firm's z-score, the coefficients in Figure 5 have the opposite sign to those in Figure 4.[19] Specifically, besides the last row, all of the coefficients on $\textit{Redesig ratio} \times \textit{Ozone ratio} \times Z$ are positive and statistically significant (at the 5% level or better), implying that firms with the corresponding characteristics are overweighted during attainment redesignations.

6. Is the portfolio response to nonattainment designations rational?

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 a rational decision driven by hedging adjustments in response to expected changes in firm fundamentals due to 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.

[19] One possible reason why firms with a high risk of distress (*Low z-score*) are not overweighted more is because these firms may not be able to benefit from attainment redesignations by shifting harm to other stakeholders. This is because, unlike the regulatory events studied in Akey and Appel (2021) that strengthens a parent firm's limited liability protection, attainment redesignations do not imply that parent firms will be protected from violations that occur at their individual facilities. Specifically, while attainment redesignations may allow a firm that is close to financial distress to forgo investments in costly pollution abatement at its polluting plants in order to free up funds for more immediate financing needs, the firm may still be liable for any violations that occur due to excess emissions at its polluting plants. In effect, attainment redesignations provide firms with more freedom in their emissions, but may not necessarily protect them from the negative consequences of additional emissions.

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:

$$
\begin{aligned}
Perf_{s,t} &= \beta_0 + \beta_1 NA\ ratio_{s,t} + \beta_2 Ozone\ ratio_{s,t-1} + \beta_3 Post_t + \beta_4 NA\ ratio_{s,t} \times Ozone\ ratio_{s,t-1} \\
&+ \beta_5 NA\ ratio_{s,t} \times Post_t + \beta_6 Ozone\ ratio_{s,t-1} \times Post_t + \beta_7 NA\ ratio_{s,t} \times Ozone\ ratio_{s,t-1} \\
&\times Post_t + X_{s,t-1} + \text{F.E.} + \varepsilon_{s,t}
\end{aligned} \tag{4}
$$

for stock s and quarter t. We focus on two quarters before to two quarters after the nonattainment designation and *Post* 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. In more stringent specifications, we use stock $\times$ industry fixed effects to control for differences within a stock-industry pair and industry $\times$ year-quarter fixed effects to control for time-varying heterogeneity at the industry level. The coefficient of interest is β_7, which measures the post-nonattainment difference in performance of heavy ozone-polluting firms exposed to nonattainment designations, as compared to less-affected firms.

We present the results in Table 10. The dependent variable *Perf* is *ROA* in columns (1) and (2), return on sales (*ROS*) 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. The coefficients on *NA ratio* $\times$ *Ozone ratio* $\times$ *Post* 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 firm with an average value of *NA ratio* and *Ozone ratio* experiences 0.18 percentage points lower ROA, corresponding to a decrease of 6.27% relative to the sample mean. Overall, the evidence from analyzing the post-nonattainment profitability of heavy ozone-polluting firms exposed to nonattainment designations is consistent with the rational hypothesis.

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 stock weight across all funds that hold the stock during the two quarters after the nonattainment designation relative to the two quarters before. Finally, 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 11 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.[20]

Panel B repeats our analysis for the least regulated firms. There is no significant per-

[20]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.

formance 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.

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, 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 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. We define *Low* Δw to be a dummy variable equal to one if a fund is in the lowest tercile, and zero otherwise. We focus on six quarters before to eight quarters after the nonattainment designation. Following Gibson, Krueger, and Mitali (2021), we 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 12 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 before the nonattainment designation.

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 enforcement

The rational hypothesis asserts that the negative impact on firm fundamentals and stock price valuations 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 we should expect the greater the exposure of these firms to nonattainment designations, the more compliance costs these firms are subject to 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, we proxy for the potential compliance costs associated with nonattainment designations by examining facilities' observable regulatory enforcement and pollution abatement efforts through source reduction activities. The intuition is that facilities with more regulatory enforcements and engagements in source reduction activities presumably have higher compliance costs.

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.[21] The other three enforcement activities are essentially evaluation tests conducted for 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.

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.

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 stock weight 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. 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, 2018).

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

Formally, we estimate the following regression specification:

$$
\begin{aligned}
reg_{s,t} &= \beta_0 + \beta_1 NA\ ratio_{s,t} + \beta_2 Underweight_{s,t} + \beta_3 Post_t + \beta_4 NA\ ratio_{s,t} \times Underweight_{s,t} \\
&+ \beta_5 NA\ ratio_{s,t} \times Post_t + \beta_6 Underweight_{s,t} \times Post_t + \beta_7 NA\ ratio_{s,t} \times Underweight_{s,t} \\
&\times Post_t + \text{Controls} + \text{F.E.} + \varepsilon_{s,t}
\end{aligned} \tag{5}
$$

for stock s and year t. *Post* 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 measure a firm's observable regulatory enforcement and pollution abatement efforts 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 most exposed to nonattainment designations in the post-nonattainment years, as compared to those that are less exposed.

Table 13 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 (in pounds) that undergo source reduction of a given firm across all of its plants located in nonattainment counties, respectively. Both coefficients on $NA\ ratio \times Underweight \times Post$ 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. 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 $NA\ ratio \times Underweight \times Post$ are all positive and statistically significant, indicating that underweighted top ozone-polluting firms face more regulatory enforcement in the post-nonattainment years, the more plants they operate in nonattainment counties. 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 on the Internet Appendix. First, 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 also control for the inherent heterogeneity of each chemical by using toxicity-weighted ozone air emissions. Additionally, to mitigate the concern of reporting errors in the TRI data, we use only core ozone chemicals, which are chemicals that have consistent reporting requirements during our sample period. Second, we conduct a falsification test by using offsite ozone emissions, which are not regulated under nonattainment status. As expected, funds do not adjust portfolio weights based on a polluting firm's offsite ozone emissions. Third, we use alternative independent variables to measure a firm's exposure to nonattainment designations. Specifically, to reflect the relative importance of a firm's different polluting plants, we use plant-level employee- and sales-weighted *NA ratio* in our baseline regressions. We also use alternative dependent variables such as Δ*Shares* and Δ*Traded value* for bump-ups and attainment redesignations. Using these alternative variables leaves our main results unchanged. Fourth, we control for firms self-selecting into nonattainment counties by using Heckman's (1979) two-stage least squares for correction.

Fifth, we examine other explanations that could explain the underweighting effect. In particular, our results could be driven by environmentally conscious funds ("sustainable funds") divesting from ozone-polluting firms to exert pressure on firms' management to reduce emissions (Azar, Duro, Kadach, & Ormazabal, 2021; Choi, Gao, Jiang, & Zhang, 2021; Gibson et al., 2021). We estimate our baseline regressions conditional on a fund's pre-nonattainment sustainability and find 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. We also 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). However, we do not find any evidence that a fund's holdings of heavy ozone-polluting firms exposed to nonattainment designations have an effect on net fund flows in subsequent quarters.

Sixth, consistent with the results that portfolio weights only respond to unexpected nonattainment designations, we find that the lower operating performance of heavy ozone-polluting firms is driven by their exposure to unexpected nonattainment designations. Furthermore, our results remain unchanged when we use buy-and-hold stock returns (Barber & Lyon, 1997) rather than CARs to study the subsequent abnormal return performance of heavy ozone-polluting stocks exposed to nonattainment regulations. Next, we conduct a falsification test by replicating 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 regulatory enforcement and source reduction activities 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. However, we show that the change in regulatory status of top ozone-polluting firms is stemming from their exposure to nonattainment designations rather than from the underweighting.

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. We posit that funds underweight (overweight) those polluting stocks whose performance covaries negatively (positively) with the regulatory shock. Using exogenous variation in local regulatory stringency resulting from nonattainment designations, we find that mutual funds underweight heavy ozone-polluting firms exposed to nonattainment designations. Our results are consistent with the rational hypothesis in that funds adjust their holdings to hedge against regulatory risk.

We verify that the underweighting effect is not driven by pre-nonattainment differential trends in portfolio weights and is robust to alternative measures of portfolio holdings, as well as high-dimensional fixed effects. The underweighting effect is prevalent regardless of a fund's distance to the nearest polluting plant, age, investment horizon, size, and concentration of stock holdings. Moreover, funds only underweight heavy ozone-polluting stocks when they are exposed to unexpected nonattainment designations. We also examine various firm characteristics that we plausibly expect to lead to more underweighting due to the imposition of additional regulatory costs. We find that the underweighting effect is stronger for firms that do not own an ozone operating permit, operate plants that are located close to nonattainment monitors, have a low environment score, operate young plants, and have a high risk of distress.

In additional analyses, we study two related types of environmental regulatory events including bump-up classifications and attainment redesignations. Consistent with the rational hypothesis, mutual funds continue to underweight heavy ozone-polluting stocks exposed to bump-ups, while they overweight such stocks during attainment redesignations. Our evidence suggests that the underweighting of heavy ozone-polluting stocks is a hedging adjustment in response to expected changes in firm fundamentals due to the costs of nonattainment regulation. Specifically, we show that heavy ozone-polluting firms exposed to nonattainment designations have worse operating performance relative to less-affected stocks. We then compare the stock return performance of underweighted top ozone emitting stocks that are highly regulated under nonattainment regulations with those that are overweighted. We find a persistent underperformance of the former stocks in the post-nonattainment period, with no signs of return reversals. The underweighting effect also translates into superior investment portfolio performance. Finally, we document that the underweighted heavy ozone-polluting stocks exposed to nonattainment designations experience an increase in regulatory enforcement in the post-nonattainment period.

Our results have potentially important policy implications. Currently, there are no federal regulations aimed at mitigating global pollutants that contribute to climate change. The findings in this study demonstrate that environmental regulations have important implications for how investors assess their portfolio holdings of polluting firms. Thus, any new climate policy must take into account the impacts on the capital allocation in financial markets.

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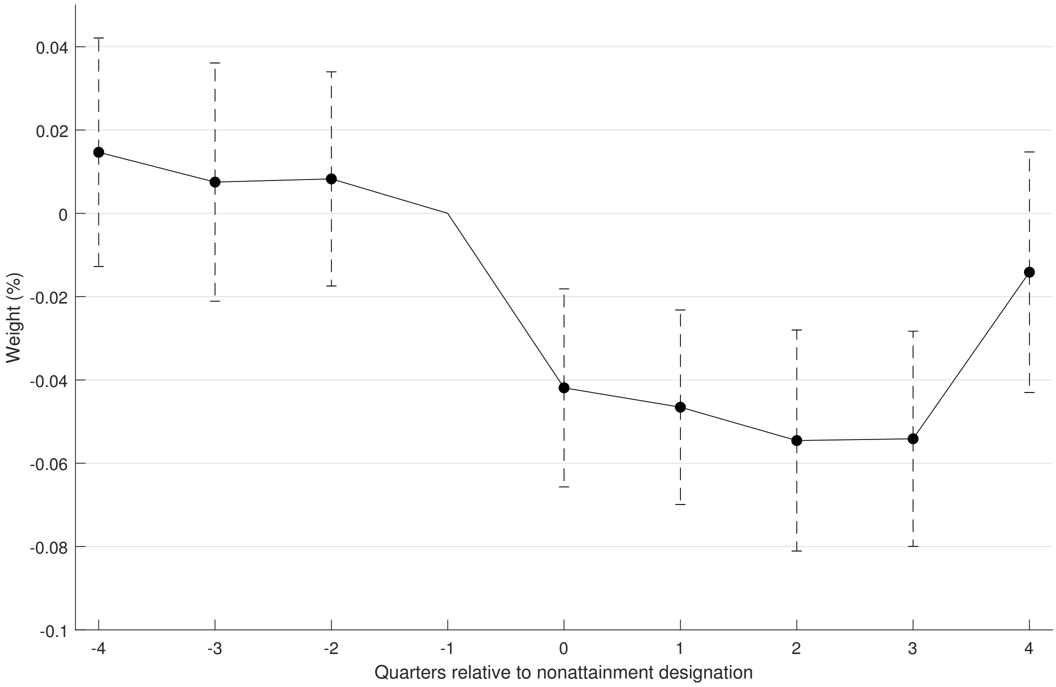
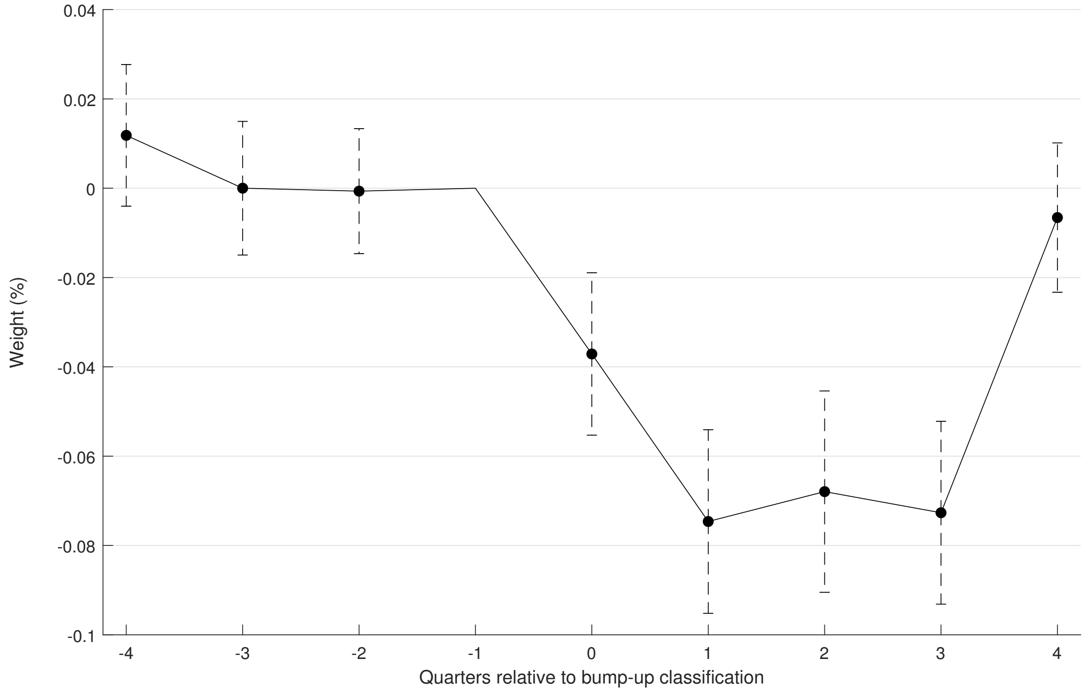
Figure 1
Dynamics of portfolio response to nonattainment designations.



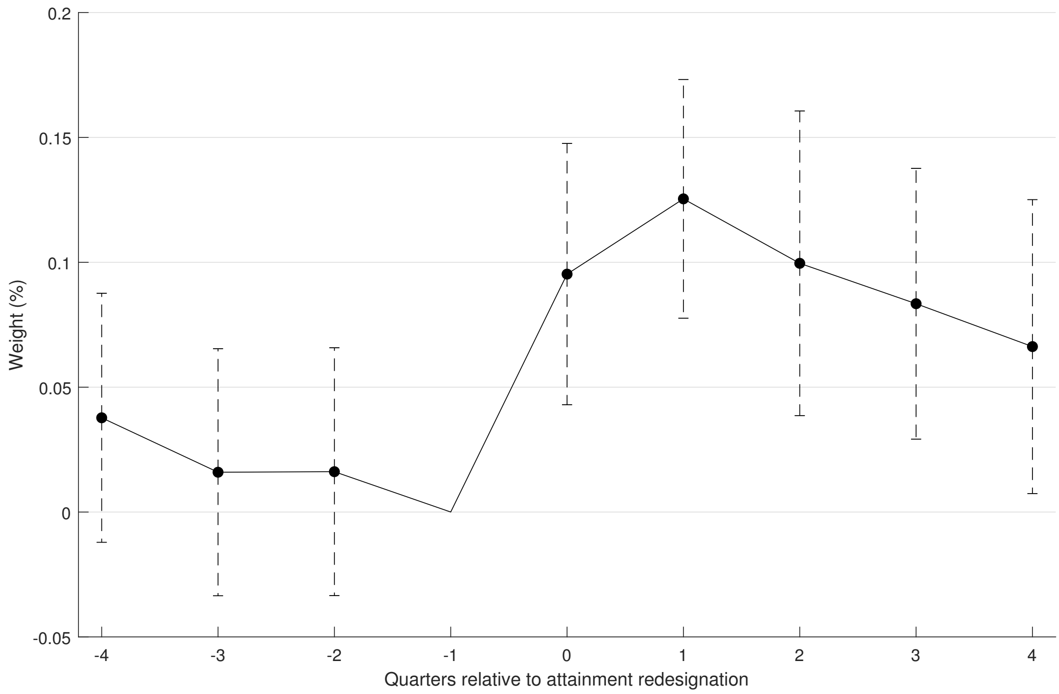
This figure shows the point estimates (solid line) and 95% confidence intervals (dashed lines) of the coefficients for the interaction term, *NA ratio*$_t$ × *Ozone ratio*$_{t-1}$ × *Post NA(k)*, where k ranges from -4 to $+4$ quarters surrounding the nonattainment designation. The quarter before the nonattainment designation is the omitted category. The dependent variable is the weight (in percentage) 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 2
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*$_t$ $\times$ *Ozone ratio*$_{t-1}$ $\times$ *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) 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.

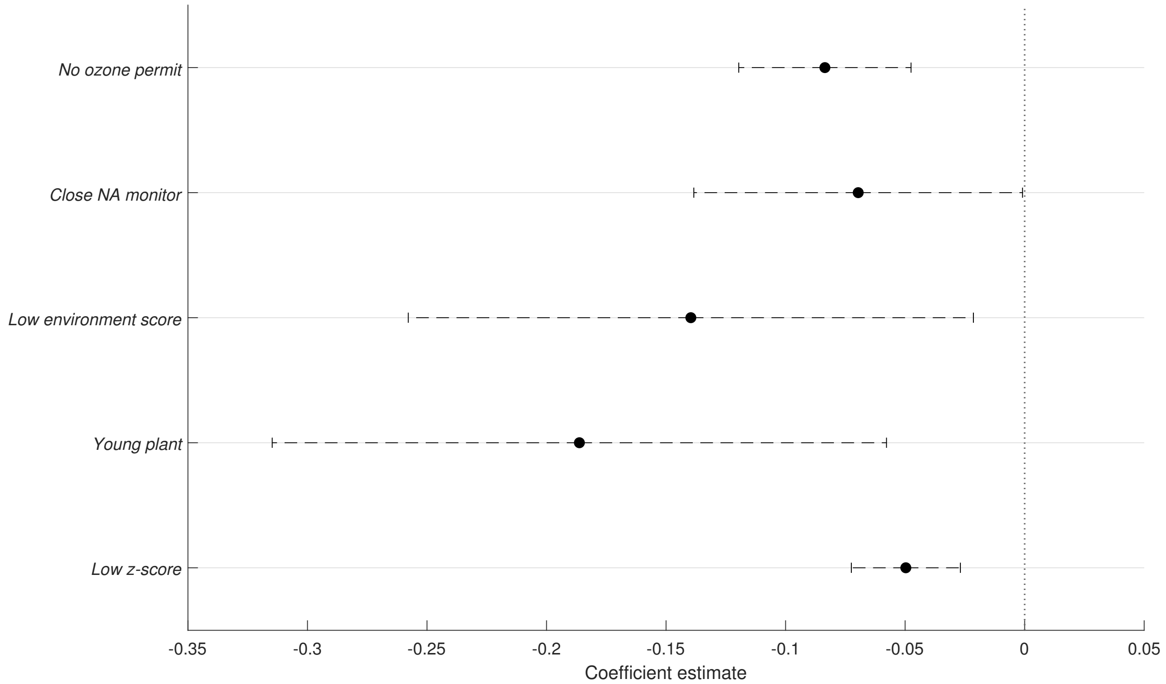
Figure 3
Dynamics of portfolio response to attainment redesignations.



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) 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 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

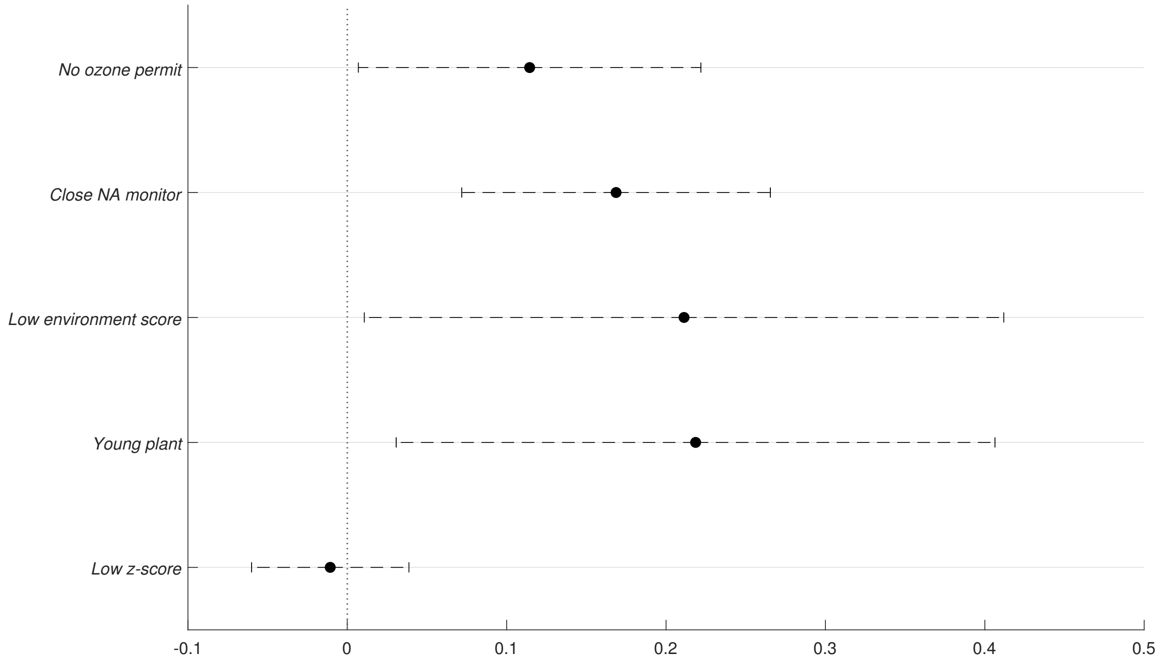
Heterogeneous portfolio responses to nonattainment designations of ozone emitting firms.



This figure shows the point estimates (black dot) and 95% confidence intervals (dashed lines) of the coefficients for the triple interaction term, $NA\ ratio_t \times Ozone\ ratio_{t-1} \times Z$ where Z refers to a set of firm characteristics. 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) 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 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. *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. *Low environment score* is a dummy variable equal to one if the difference between the average strength and concern environment scores for a given firm is below the median. *Young plant* is a dummy variable equal to one if the average plant age of a given firm is between zero and five years. *Low z-score* is a dummy variable equal to one if the Altman's unlevered z-score for a given firm is below the median.

Figure 5

Heterogeneous portfolio responses to attainment redesignations of ozone emitting firms.



This figure shows the point estimates (black dot) and 95% confidence intervals (dashed lines) of the coefficients for the triple interaction term, *Redesig* $ratio_t \times$ *Ozone* $ratio_{t-1} \times Z$ where Z refers to a set of firm characteristics. 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) 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 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. *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. *Low environment score* is a dummy variable equal to one if the difference between the average strength and concern environment scores for a given firm is below the median. *Young plant* is a dummy variable equal to one if the average plant age of a given firm is between zero and five years. *Low z-score* is a dummy variable equal to one if the Altman's unlevered z-score for a given firm is below the median.

Table 1

Distribution of county characteristics by state.

State	# TRI parent firms per county	# TRI ozone plants per county	# TRI non-ozone plants per county	# Counties nonattainment	# Counties bump-up	# Counties redesignated	# Counties total
Alaska	0.12	0.10	0.04	0	0	0	29
Alabama	1.51	0.75	0.91	2	0	2	67
Arkansas	1.19	0.53	0.85	1	1	1	75
Arizona	3.03	1.78	1.83	4	2	2	15
California	4.23	2.46	2.73	42	28	5	58
Colorado	0.69	0.32	0.44	9	9	7	64
Connecticut	6.44	4.00	4.03	8	8	0	8
District of Columbia	1.80	0.00	2.40	1	1	1	1
Delaware	4.67	3.01	1.76	3	0	0	3
Florida	1.66	0.81	0.94	7	0	7	67
Georgia	0.90	0.46	0.52	23	20	23	159
Hawaii	1.40	2.08	0.53	0	0	0	5
Iowa	0.93	0.54	0.47	0	0	0	99
Idaho	0.26	0.13	0.14	0	0	0	44
Illinois	1.79	1.04	1.01	12	11	12	102
Indiana	2.00	1.14	1.13	24	2	24	92
Kansas	0.57	0.30	0.31	2	0	2	105
Kentucky	0.77	0.43	0.38	16	0	16	120
Louisiana	1.34	0.97	0.56	17	5	17	64
Massachusetts	5.19	2.67	3.02	14	0	0	14
Maryland	1.39	0.63	0.88	14	11	7	24
Maine	1.21	0.73	0.56	12	0	11	16
Michigan	1.69	1.07	1.07	39	0	39	83
Minnesota	1.18	0.59	0.67	0	0	0	87
Missouri	0.94	0.44	0.56	8	5	8	115
Mississippi	0.86	0.40	0.57	1	0	1	82
Montana	0.18	0.14	0.07	0	0	0	56
North Carolina	1.61	0.81	0.94	23	0	23	100
North Dakota	0.27	0.15	0.12	0	0	0	53
Nebraska	0.43	0.20	0.29	0	0	0	93
New Hampshire	2.23	0.90	1.55	7	0	6	10
New Jersey	3.56	2.02	1.75	21	12	0	21
New Mexico	0.54	0.32	0.30	1	0	0	33
Nevada	1.18	0.59	0.69	2	1	1	17
New York	1.92	0.95	1.11	30	28	0	62
Ohio	2.99	1.63	1.75	34	0	34	88
Oklahoma	0.93	0.41	0.61	0	0	0	77
Oregon	1.18	0.69	0.69	5	0	3	36
Pennsylvania	2.96	1.55	1.77	49	7	32	67
Rhode Island	3.22	1.51	1.79	5	0	0	5
South Carolina	2.03	1.09	1.01	2	0	2	46
South Dakota	0.24	0.11	0.16	0	0	0	66
Tennessee	1.43	0.64	0.88	14	1	14	95
Texas	1.27	0.73	0.82	23	21	4	254
Utah	1.29	0.66	0.83	7	0	2	29
Virginia	0.70	0.29	0.44	37	10	36	133
Vermont	0.38	0.19	0.30	0	0	0	14
Washington	1.24	0.63	0.77	4	0	4	39
Wisconsin	1.94	1.13	1.08	11	2	11	72
West Virginia	0.72	0.50	0.27	10	0	10	55
Wyoming	0.55	0.43	0.16	3	0	0	23

This table reports the average number of TRI parent firms per county, the average number of TRI ozone plants per county, the average number of TRI non-ozone plants per county, the number of counties ever obtained a nonattainment designation, the number of counties ever experienced a bump-up classification, the number of counties ever obtained an attainment redesignation, and the total number of counties. 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
Fund distance (km)	861.658	507.586	981.965	176.062	1129.274	317,761
Fund age	11.302	9.000	10.258	4.000	16.000	176,100
Churn ratio	0.068	0.056	0.050	0.036	0.086	156,272
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
Environment score	0.061	0.000	0.239	0.000	0.167	7,679
Young plant	0.056	0.000	0.229	0.000	0.000	1,632
Z-score	0.506	0.952	29.720	0.514	1.350	62,867
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	0.105	0.000	0.232	0.000	0.091	1,632
Antic. NA ratio	0.235	0.106	0.310	0.000	0.333	1,632
Bump ratio	0.408	0.267	0.351	0.125	0.667	864
Unexp. bump ratio	0.196	0.000	0.312	0.000	0.250	864
Antic. bump ratio	0.213	0.067	0.313	0.000	0.286	864
Redesig ratio	0.083	0.000	0.187	0.000	0.071	1,398
Unexp. redesig ratio	0.060	0.000	0.166	0.000	0.024	1,398
Antic. redesig ratio	0.023	0.000	0.101	0.000	0.000	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 of ozone emitting firms 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)
$NA\ ratio_t \times Ozone\ ratio_{t-1}$	-0.018**	-0.027***	-0.018**	-0.026***	-0.027***	-0.024***	-0.025**
	(-2.33)	(-3.10)	(-2.20)	(-2.79)	(-2.62)	(-2.62)	(-2.44)
$ln(Size)_{t-1}$		-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) 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 exits of ozone emitting firms in response to nonattainment designations.

Dep. variable: *Exit*	(1)	(2)	(3)	(4)
$NA\ ratio_t$	-0.013***	-0.011***	-0.014***	-0.011***
	(-3.90)	(-2.86)	(-3.90)	(-2.86)
$Ozone\ ratio_{t-1}$	-0.019***	-0.006	-0.019***	-0.007
	(-5.08)	(-1.41)	(-4.97)	(-1.57)
$NA\ ratio_t \times Ozone\ ratio_{t-1}$	0.015***	0.013**	0.015***	0.014**
	(2.57)	(1.96)	(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	339,540	205,867	339,539	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 with the dependent variable as *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 5
Alternative measures of portfolio response to nonattainment designations of ozone emitting firms.

Dep. variable:	Δ*Shares*		Δ*Traded value*	
	(1)	(2)	(3)	(4)
$NA\ ratio_t$	0.005	0.008	0.378***	0.455***
	(0.72)	(0.52)	(4.16)	(3.66)
$Ozone\ ratio_{t-1}$	0.007	0.011	0.361***	0.496***
	(0.70)	(0.76)	(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)
$ln(Size)_{t-1}$	-0.001**	-0.001	-0.098***	-0.192***
	(-2.06)	(-1.41)	(-4.34)	(-5.61)
$ln(BM)_{t-1}$	0.011	0.013	0.478**	0.695*
	(1.29)	(0.92)	(1.98)	(1.92)
ROA_{t-1}	0.027	0.016	-1.751	-4.251**
	(1.46)	(0.67)	(-1.16)	(-1.99)
$Leverage_{t-1}$	-0.005	-0.008	0.044	-0.186
	(-0.75)	(-0.71)	(0.33)	(-0.88)
$Sales\ growth_{t-1}$	-0.001	-0.004	-0.051	-0.007
	(-0.48)	(-0.92)	(-0.50)	(-0.05)
$Momentum_{t-1}$	0.002	0.002*	0.003	-0.023
	(1.59)	(1.78)	(0.10)	(-0.50)
$Stock\ returns_t$	-0.000	-0.001	0.328*	0.523**
	(-0.04)	(-0.37)	(1.95)	(2.07)
$Expense\ ratio_{t-1}$	0.281		12.656	
	(0.98)		(1.33)	
$Turnover\ ratio_{t-1}$	-0.001		0.017	
	(-0.65)		(0.49)	
$ln(Fund\ size)_{t-1}$	0.001		0.029	
	(0.57)		(0.90)	
$Net\ flow_{t-1}$	0.023***		1.559***	
	(6.03)		(7.20)	
$Fund\ returns_{t-1}$	0.197*		11.723***	
	(1.69)		(4.77)	
Constant	-0.004	0.003	0.131	1.401***
	(-0.35)	(0.31)	(0.31)	(3.37)
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	205,726	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) during the quarters after the nonattainment designation relative to the quarters before. The dependent variable in columns (3) and (4) is the change in 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 6

Fund characteristics and portfolio response to nonattainment designations of ozone emitting firms.

	Fund distance		Fund age		Churn ratio		ln(Fund size)		Number of stocks		Concentration	
	Above	Below	Above	Below	Above	Below	Above	Below	Above	Below	Above	Below
Dep. variable: Δw	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)	(9)	(10)	(11)	(12)
NA ratio$_t$	0.026***	0.014***	0.020***	0.019***	0.017***	0.024***	0.018***	0.021***	0.014***	0.030***	0.038***	0.008***
	(7.10)	(3.33)	(6.10)	(4.16)	(4.79)	(5.78)	(6.26)	(4.20)	(5.60)	(5.13)	(6.45)	(3.43)
Ozone ratio$_{t-1}$	0.043***	0.023***	0.028***	0.034***	0.027***	0.035***	0.024***	0.039***	0.021***	0.048***	0.053***	0.016***
	(11.37)	(5.51)	(8.25)	(6.88)	(7.70)	(7.64)	(7.64)	(7.57)	(8.81)	(7.14)	(8.33)	(6.79)
NA ratio$_t$ $\times$ *Ozone ratio*$_{t-1}$	-0.025***	-0.018**	-0.029***	-0.029***	-0.028***	-0.031***	-0.019***	-0.044***	-0.014***	-0.058***	-0.059***	-0.012**
	(-2.73)	(-2.01)	(-4.20)	(-3.00)	(-3.72)	(-3.56)	(-3.05)	(-3.95)	(-2.72)	(-4.58)	(-4.51)	(-2.58)
Coefficient difference	-0.007		-0.001		0.003		0.025**		0.044***		-0.047***	
p-value	0.421		0.889		0.500		0.047		0.004		0.001	
Stock controls	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes
Fund controls	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes
Fund F.E.	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes
Stock F.E.	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes
Year-Quarter F.E.	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes
Observations	158,865	158,858	199,307	140,675	198,885	140,152	198,529	141,452	215,164	124,818	134,243	205,739
Adj R^2	0.04	0.04	0.02	0.05	0.03	0.05	0.03	0.04	0.02	0.04	0.03	0.06

This table reports the regression estimates from Equation (1) at the fund-firm-quarter level for subsamples based on fund characteristics. 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) 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. Columns (1) and (2) report the results for the subsample of funds where the distance between a fund's headquarters and the closest polluting plant of a given firm is above ("Far") and below ("Close") the median, respectively. Columns (3) and (4) report the results for the subsample of funds with fund age above ("Old") and below ("Young") the median, respectively. Columns (5) and (6) report the results for the subsample of funds with a churn ratio above ("Short-term") and below ("Long-term") the median, respectively. Columns (7) and (8) report the results for the subsample of funds with a (log) fund size above ("Large") and below ("Small") the median, respectively. Columns (9) and (10) report the results for the subsample of funds with the number of stocks above ("Diversified") and below ("Concentrated") the median, respectively. Columns (11) and (12) report the results for the subsample of funds with HHI concentration above ("Concentrated") and below ("Diversified") the median, respectively. Coefficient difference represents the difference in the coefficient estimates of *NA ratio* $\times$ *Ozone ratio* in the "Above" group relative to the "Below" group. 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
Portfolio response to unexpected and anticipated nonattainment designations of ozone emitting firms.

Dep. variable: Δw	(1)	(2)	(3)	(4)
Unexp. NA ratio$_t$	0.043***	0.041***	0.045***	0.044***
	(4.85)	(3.83)	(5.03)	(4.16)
Antic. NA ratio$_t$	0.012**	0.017***	0.010*	0.014**
	(2.17)	(2.63)	(1.90)	(2.25)
Ozone ratio$_{t-1}$	0.020***	0.012*	0.018***	0.010
	(3.10)	(1.67)	(2.77)	(1.43)
Unexp. NA ratio$_t$ $\times$ *Ozone ratio*$_{t-1}$	-0.135***	-0.139***	-0.136***	-0.144***
	(-6.65)	(-5.90)	(-6.67)	(-6.12)
Antic. NA ratio$_t$ $\times$ *Ozone ratio*$_{t-1}$	0.004	0.002	0.007	0.006
	(0.40)	(0.21)	(0.65)	(0.55)
Stock controls	Yes	Yes	Yes	Yes
Fund controls	Yes	Yes	No	No
Fund $\times$ Stock F.E.	No	Yes	No	Yes
Fund $\times$ 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 by decomposing nonattainment designations 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) 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 8

Changes in portfolio weights of ozone emitting firms 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$_t$ $\times$ *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 $\times$ Stock F.E.	No	Yes	No	Yes
Fund $\times$ 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$_t$	0.022***	0.021***	0.014*	0.011
	(3.10)	(2.77)	(1.95)	(1.50)
Antic. bump ratio$_t$	0.029***	0.022**	0.030***	0.021**
	(3.42)	(2.32)	(3.45)	(2.25)
Ozone ratio$_{t-1}$	0.046***	0.043***	0.050***	0.047***
	(4.17)	(3.69)	(4.42)	(3.86)
Unexp. bump ratio$_t$ $\times$ *Ozone ratio*$_{t-1}$	-0.110***	-0.103***	-0.110***	-0.096***
	(-6.59)	(-5.93)	(-6.58)	(-5.51)
Antic. bump ratio$_t$ $\times$ *Ozone ratio*$_{t-1}$	-0.098***	-0.086***	-0.093***	-0.080***
	(-4.44)	(-3.54)	(-4.20)	(-3.24)
Stock controls	Yes	Yes	Yes	Yes
Fund controls	Yes	Yes	No	No
Fund $\times$ Stock F.E.	No	Yes	No	Yes
Fund $\times$ 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 (2) 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) 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 9
Changes in portfolio weights of ozone emitting firms in response to attainment redesignations.

Panel A: Baseline attainment redesignations

Dep. variable: Δw	(1)	(2)	(3)	(4)
Redesig ratio$_t$	0.022*	0.020	0.025*	0.023
	(1.69)	(1.44)	(1.72)	(1.46)
Ozone ratio$_{t-1}$	0.022***	0.027***	0.011	0.014
	(2.74)	(2.87)	(1.35)	(1.39)
Redesig ratio$_t$ $\times$ *Ozone ratio*$_{t-1}$	0.137***	0.152***	0.074***	0.069**
	(5.09)	(5.23)	(2.66)	(2.27)
Stock controls	Yes	Yes	Yes	Yes
Fund controls	Yes	Yes	No	No
Fund $\times$ Stock F.E.	No	Yes	No	Yes
Fund $\times$ Year-Quarter F.E.	No	No	Yes	Yes
Fund F.E.	Yes	No	No	No
Stock F.E.	Yes	No	Yes	No
Year-Quarter F.E.	Yes	Yes	No	No
Observations	373,808	305,932	364,474	293,765
Adj R^2	0.03	0.03	0.11	0.15

Panel B: Decomposition of attainment redesignations

Dep. variable: Δw	(1)	(2)	(3)	(4)
Unexp. redesig ratio$_t$	0.039**	0.040**	0.028	0.020
	(2.24)	(2.33)	(1.37)	(0.92)
Antic. redesig ratio$_t$	0.006	0.000	-0.004	0.003
	(0.32)	(0.01)	(-0.24)	(0.15)
Ozone ratio$_{t-1}$	0.023***	0.027***	-0.001	0.016
	(2.89)	(2.95)	(-0.13)	(1.52)
Unexp. redesig ratio$_t$ $\times$ *Ozone ratio*$_{t-1}$	0.147***	0.155***	0.090**	0.108***
	(4.81)	(4.82)	(2.58)	(2.92)
Antic. redesig ratio$_t$ $\times$ *Ozone ratio*$_{t-1}$	-0.002	0.023	0.018	0.088
	(-0.04)	(0.37)	(0.27)	(1.42)
Stock controls	Yes	Yes	Yes	Yes
Fund controls	Yes	Yes	No	No
Fund $\times$ Stock F.E.	No	Yes	No	Yes
Fund $\times$ Year-Quarter F.E.	No	No	Yes	Yes
Fund F.E.	Yes	No	No	No
Stock F.E.	Yes	No	Yes	No
Year-Quarter F.E.	Yes	Yes	No	No
Observations	373,808	305,932	363,426	293,744
Adj R^2	0.03	0.03	0.11	0.14

This table examines the changes in portfolio weights in response to attainment redesignations. Panel A reports the regression estimates from Equation (3) 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) 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 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 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 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 10
Operating performance of ozone emitting firms around nonattainment designations.

Dep. variable:	ROA_t		ROS_t		$Sales\ growth_t$	
	(1)	(2)	(3)	(4)	(5)	(6)
$NA\ ratio_t$	0.003	0.002	-0.017	-0.008	-0.041	-0.056
	(0.73)	(0.43)	(-1.30)	(-0.54)	(-1.43)	(-1.54)
$Ozone\ ratio_{t-1}$	0.000	-0.000	-0.011	-0.008	-0.026	-0.023
	(0.06)	(-0.16)	(-1.22)	(-0.79)	(-1.60)	(-1.13)
$Post_t$	-0.000	-0.000	-0.004	-0.004	-0.036***	-0.028***
	(-0.42)	(-0.41)	(-0.98)	(-0.97)	(-3.62)	(-2.88)
$NA\ ratio_t \times Ozone\ ratio_{t-1}$	-0.002	-0.006	0.006	-0.016	0.032	0.019
	(-0.25)	(-0.62)	(0.28)	(-0.58)	(0.75)	(0.30)
$NA\ ratio_t \times Post_t$	0.008**	0.008**	0.022*	0.022*	0.076*	0.058
	(1.98)	(1.98)	(1.68)	(1.67)	(1.90)	(1.61)
$Ozone\ ratio_{t-1} \times Post_t$	0.002	0.002	0.009	0.009	0.039**	0.042**
	(1.23)	(1.22)	(1.56)	(1.53)	(2.26)	(2.40)
$NA\ ratio_t \times Ozone\ ratio_{t-1} \times Post_t$	-0.015***	-0.015***	-0.040**	-0.040**	-0.112**	-0.107**
	(-2.64)	(-2.63)	(-2.28)	(-2.26)	(-2.00)	(-2.09)
$ln(Size)_{t-1}$	0.000	0.000	0.012***	0.013***	-0.014***	-0.033***
	(0.19)	(0.33)	(2.99)	(2.77)	(-2.71)	(-3.79)
$ln(BM)_{t-1}$	-0.033***	-0.038***	-0.014	0.000	-0.039	-0.374***
	(-5.70)	(-6.08)	(-0.71)	(0.02)	(-1.02)	(-6.78)
ROA_{t-1}	0.472***	0.449***	0.263***	0.237**	0.918*	-4.243***
	(4.41)	(4.55)	(2.87)	(2.51)	(1.92)	(-5.15)
ROS_{t-1}	0.027	0.032**	0.697***	0.696***	0.003	0.547***
	(1.49)	(2.01)	(13.70)	(13.78)	(0.02)	(3.59)
$Leverage_{t-1}$	0.007*	0.007*	0.019	0.019	-0.032	-0.114***
	(1.87)	(1.65)	(1.58)	(1.53)	(-1.38)	(-2.96)
$Sales\ growth_{t-1}$	-0.015***	-0.016***	-0.004	-0.006	-0.215***	-0.139***
	(-4.98)	(-5.16)	(-0.61)	(-0.76)	(-4.26)	(-2.62)
$Momentum_{t-1}$	0.001*	0.001**	0.002	0.003*	-0.002	-0.002
	(1.81)	(2.10)	(1.23)	(1.79)	(-0.31)	(-0.33)
$Stock\ returns_t$	0.002	-0.001	-0.004	0.003	0.061**	0.050*
	(1.08)	(-0.34)	(-0.54)	(0.40)	(2.08)	(1.80)
Constant	0.027***	0.029***	-0.052	-0.071*	0.160***	0.582***
	(4.23)	(3.85)	(-1.53)	(-1.77)	(3.09)	(7.03)
Stock × Industry F.E.	No	Yes	No	Yes	No	Yes
Industry × Year-Quarter F.E.	No	Yes	No	Yes	No	Yes
Stock F.E.	Yes	No	Yes	No	Yes	No
Industry F.E.	Yes	No	Yes	No	Yes	No
Year-Quarter F.E.	Yes	No	Yes	No	Yes	No
Observations	6,192	6,192	6,152	6,152	6,260	6,260
Adj R^2	0.61	0.62	0.55	0.55	0.06	0.12

This table reports the regression estimates from Equation (4) at the firm-quarter level. We focus on two quarters before to two quarters after the nonattainment designation. The dependent variable is *ROA* in columns (1) and (2), *ROS* 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. *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* 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 11

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 12
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 13

Underweighting and regulatory enforcement of top ozone emitting firms around nonattainment designations.

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)
$Post_t$	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)
$NA\ ratio_t \times Underweight_t$	-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)
$NA\ ratio_t \times Post_t$	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)
$Underweight_t \times Post_t$	-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)
$NA\ ratio_t \times Underweight_t \times Post_t$	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 (5) 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 (in pounds) 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* 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) 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) 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).	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) 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.	Thomson Reuters mutual fund holdings (s12); CRSP
Δ*Traded value*	The change in 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 $100 \times (TNA_t - (1 + \mathit{Fund\ returns}_t) \times TNA_{t-1}) \,/\, TNA_{t-1}$.	CRSP Mutual Funds
Fund distance	The distance (in km) between a fund's headquarters and the closest polluting plant of a given firm.	CRSP Mutual Funds; TRI
Fund age	The number of years a given fund has been in existence since its inception.	CRSP Mutual Funds
Churn ratio	The churn ratio calculated according to the procedure in Gaspar et al. (2005). To smooth out measurement errors, the churn ratio of a fund-quarter is calculated as the moving-average churn ratio of the four trailing quarters.	Thomson Reuters mutual fund holdings (s12); CRSP
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)

Table A.1 continued

Variable	Definitions	Data source
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
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
Environment score	The difference between the average strength and concern environment scores for a given firm.	KLD
Young plant	A dummy variable equal to one if the average plant age of a given firm is between zero and five years.	NETS
Z-score	Altman's unlevered z-score for a given firm.	Compustat
Ozone ratio	The ozone air emissions (in pounds) for a given plant as a proportion of the plant's overall air emissions (in pounds) averaged across all plants owned by a given firm.	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 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 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 plants owned by the firm.	TRI; Federal Register; AQS

Table A.1 continued

Variable	Definitions	Data source
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 (in pounds) 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

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Appendix IA. Additional robustness tests

IA.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* $\times$ *Ozone ratio* is always negative and statistically significant, which is similar to our baseline results in Table 3.

IA.2. 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.3), bump-up classifications (Internet Appendix Table IA.11), and attainment redesignations (Internet Appendix Table IA.13) using *TW ozone ratio* and find robust results.

IA.3. 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.4 shows that our results hold in this robustness check.

IA.4. 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.5, confirming the falsification test.

IA.5. 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.6 shows that our main results remain intact when using these two variables in place of *NA ratio* in the estimation of Equation (1).

IA.6. Alternative dependent variables for bump-up classifications and attainment redesignations

We replicate the analyses in Section 5.1.3 by using Δ*Shares* and Δ*Traded value* as alternative measures of portfolio response to bump-up classifications (Internet Appendix Table IA.10) and attainment redesignations (Internet Appendix Table IA.12). Our findings remain qualitatively unchanged.

IA.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 hypothetical nonattainment status 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.7 presents the first-stage estimation results. As expected, a county's hypothetical nonattainment status based on prior year DVs positively predicts future 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:

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

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.7. 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.

IA.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 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.8. Across all columns, the coefficients 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.

IA.9. Competing 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 competition for 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:

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

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.9, none of the coefficients on *vw-NA ratio* × *vw-Ozone ratio* are statistically significant, indicating that competition for ESG investment flows does not appear to be driving our results.

IA.10. Operating performance around unexpected and anticipated nonattainment designations.

Since portfolio weights only respond to unexpected nonattainment designations, we expect the underperformance of heavy ozone-polluting firms to be concentrated in those that operate a majority of plants in unexpected nonattainment counties. To test this, we estimate Equation (4), but decompose *NA ratio* into *Unexp. NA ratio* and *Antic. NA ratio*. Internet Appendix Table IA.14 confirms this prediction, since only the coefficients on *Unexp. NA ratio* × *Ozone ratio* × *Post* are negative and statistically significant.

IA.11. 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.15.

IA.12. Underweighting and regulatory enforcement of low ozone emitting firms

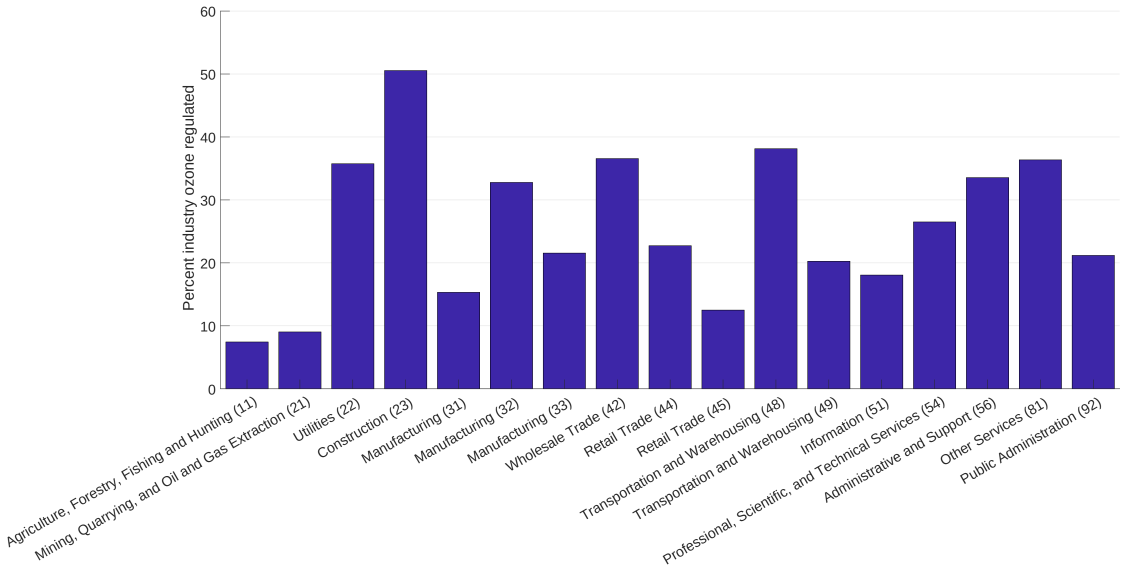
Section 7 documents that underweighted top ozone-polluting firms operating a majority of plants in nonattainment counties are subject to more regulatory enforcement and engage in more pollution abatement. Since low ozone emitting firms are less impacted by the NAAQS, regardless of their exposure to nonattainment designations, we expect that the regulatory enforcement and source reduction activities of underweighted *low* ozone-polluting firms should not depend on their exposure to nonattainment designations. Consistent with this prediction, Internet Appendix Table IA.16 estimates Equation (5) using the sample of low ozone emitting firms and find that the coefficients on *NA ratio* × *Underweight* × *Post* are all statistically indistinguishable from zero, except for the number of Title V inspections, where the coefficient is positive and statistically significant, but much smaller in magnitude.

IA.13. Is underweighting causing a change in firm behavior?

Kim, Wan, Wang, and Yang (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 (5) 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.[22] The intuition is that if underweighting causes a change in firm behavior, then it should lead to an observable change in the aforementioned outcome variables in the post-nonattainment period. Internet Appendix Table IA.17 shows that the coefficients on *NA ratio* × *Underweight* × *Post* 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.

[22]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).

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.

Table IA.1
Ozone NAAQS.

Standard	Effective date	Averaging time	Threshold (ppm)	Form
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
1997	June 15, 2004	8 hours	0.08	Annual fourth-highest daily maximum 8-hr concentration, averaged over 3 years
2008	July 20, 2012	8 hours	0.075	Annual fourth-highest daily maximum 8-hr concentration, averaged over 3 years
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. Standard refers to the name of the ozone NAAQS. Effective date is the effective nonattainment designation date. 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.

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

Changes in portfolio weights of ozone emitting firms 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) 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.4
Changes in portfolio weights of ozone emitting firms 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***	0.060***	0.046***	0.054***
	(5.20)	(5.39)	(4.77)	(4.86)
Ozone ratio$_{t-1}$	0.016**	0.007	0.016**	0.004
	(1.99)	(0.78)	(2.10)	(0.45)
NA ratio$_t$ $\times$ *Ozone ratio*$_{t-1}$	-0.051***	-0.061***	-0.045***	-0.052***
	(-3.95)	(-4.20)	(-3.49)	(-3.57)
Stock controls	Yes	Yes	Yes	Yes
Fund controls	Yes	Yes	No	No
Fund $\times$ Stock F.E.	No	Yes	No	Yes
Fund $\times$ 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) 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.5
Changes in portfolio weights of ozone emitting firms in response to nonattainment designations, using offsite emissions.

Dep. variable: Δw	(1)	(2)	(3)	(4)
NA ratio$_t$	0.007	0.010*	0.007	0.010*
	(1.49)	(1.95)	(1.47)	(1.84)
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 $\times$ Stock F.E.	No	Yes	No	Yes
Fund $\times$ 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) 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.6

Changes in portfolio weights of ozone emitting firms 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$_t$	0.010**	0.010**	0.011**	0.011**
	(2.27)	(2.00)	(2.34)	(2.20)
Ozone ratio$_{t-1}$	0.011**	-0.004	0.012**	-0.002
	(2.02)	(-0.59)	(2.16)	(-0.33)
Employee NA ratio$_t$ $\times$ *Ozone ratio*$_{t-1}$	-0.028***	-0.023**	-0.028***	-0.023***
	(-3.53)	(-2.56)	(-3.52)	(-2.59)
Stock controls	Yes	Yes	Yes	Yes
Fund controls	Yes	Yes	No	No
Fund $\times$ Stock F.E.	No	Yes	No	Yes
Fund $\times$ 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$_t$	0.007*	0.009*	0.008*	0.009*
	(1.65)	(1.67)	(1.74)	(1.83)
Ozone ratio$_{t-1}$	0.011**	-0.002	0.011**	-0.002
	(1.97)	(-0.28)	(2.12)	(-0.31)
Sales NA ratio$_t$ $\times$ *Ozone ratio*$_{t-1}$	-0.027***	-0.024***	-0.027***	-0.023**
	(-3.29)	(-2.69)	(-3.31)	(-2.56)
Stock controls	Yes	Yes	Yes	Yes
Fund controls	Yes	Yes	No	No
Fund $\times$ Stock F.E.	No	Yes	No	Yes
Fund $\times$ 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) 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.7
Changes in portfolio weights of ozone emitting firms in response to nonattainment designations, using Heckman correction.

	First stage		Second stage			
Dep. variable: NA_t	(1)	Dep. variable: Δw	(2)	(3)	(4)	(5)
NA DV_{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-county emp $ratio_{t-1}$	0.153**	*NA* $ratio_t$ × *Ozone* $ratio_{t-1}$	-0.026***	-0.027**	-0.025***	-0.028***
	(2.02)		(-2.77)	(-2.56)	(-2.58)	(-2.67)
Δ*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 *NA* DV_{t-1}, which is a dummy variable equal to one if the county is hypothetically in nonattainment based on DVs; *ln(County emp)*$_{t-1}$, defined as the natural logarithm of one plus the employment levels in a given county; *NOx-county emp* $ratio_{t-1}$, defined as a given county's NO_x emissions to employment ratio; Δ*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) 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 of ozone emitting firms in response to nonattainment designations, conditional on funds' sustainability.

Dep. variable: Δw	(1)	(2)	(3)	(4)
NA ratio$_t$	0.010	0.010	0.010*	0.010
	(1.62)	(1.38)	(1.66)	(1.29)
Ozone ratio$_{t-1}$	0.015*	0.026**	0.015*	0.025**
	(1.80)	(2.48)	(1.73)	(2.38)
vw-Environment score$_{t-1}$	-0.001	-0.018		
	(-0.05)	(-0.75)		
NA ratio$_t$ $\times$ *Ozone ratio*$_{t-1}$	-0.028**	-0.044***	-0.030**	-0.044***
	(-2.25)	(-2.84)	(-2.46)	(-2.85)
NA ratio$_t$ $\times$ *vw-Environment score*$_{t-1}$	0.022	0.122**	0.013	0.121**
	(0.56)	(2.23)	(0.32)	(2.26)
Ozone ratio$_{t-1}$ $\times$ *vw-Environment score*$_{t-1}$	-0.008	-0.091*	-0.018	-0.096**
	(-0.27)	(-1.87)	(-0.63)	(-1.98)
NA ratio$_t$ $\times$ *Ozone ratio*$_{t-1}$ $\times$ *vw-Environment score*$_{t-1}$	-0.138	-0.013	-0.154	-0.065
	(-1.05)	(-0.05)	(-1.20)	(-0.27)
Stock controls	Yes	Yes	Yes	Yes
Fund controls	Yes	Yes	No	No
Fund $\times$ Stock F.E.	No	Yes	No	Yes
Fund $\times$ 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) 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.9

The effect of portfolio exposure to nonattainment designations and firm pollution 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$_t$ $\times$ *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 (IA.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.10
Alternative measures of portfolio response to bump-up classifications of ozone emitting firms.

Dep. variable:	Δ*Shares*		Δ*Traded value*	
	(1)	(2)	(3)	(4)
Bump ratio$_t$	0.005***	0.005***	0.047	0.070
	(3.45)	(3.11)	(0.41)	(0.49)
Ozone ratio$_{t-1}$	0.002	0.003	0.461**	0.524**
	(1.47)	(1.45)	(2.54)	(2.45)
Bump ratio$_t$ $\times$ *Ozone ratio*$_{t-1}$	-0.006**	-0.006**	-1.158***	-1.267***
	(-2.54)	(-2.14)	(-3.41)	(-3.48)
Stock controls	Yes	Yes	Yes	Yes
Fund controls	Yes	No	Yes	No
Fund $\times$ Stock F.E.	No	Yes	No	Yes
Fund $\times$ 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 (2) 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) during the quarters after the bump-up classification relative to the quarters before. The dependent variable in columns (3) and (4) is the change in 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.11
Changes in portfolio weights of ozone emitting firms in response to bump-up classifications, using toxicity-weighted emissions.

Dep. variable: Δw	(1)	(2)	(3)	(4)
Bump ratio$_t$	0.024***	0.023***	0.021***	0.018**
	(3.52)	(3.12)	(2.97)	(2.34)
TW ozone ratio$_{t-1}$	0.034***	0.039***	0.034***	0.038***
	(3.68)	(4.01)	(3.68)	(3.78)
Bump ratio$_t$ $\times$ *TW ozone ratio*$_{t-1}$	-0.082***	-0.084***	-0.080***	-0.077***
	(-5.52)	(-5.30)	(-5.36)	(-4.77)
Stock controls	Yes	Yes	Yes	Yes
Fund controls	Yes	Yes	No	No
Fund $\times$ Stock F.E.	No	Yes	No	Yes
Fund $\times$ 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 reports the regression estimates from Equation (2) at the fund-firm-quarter level using toxicity-weighted ozone emissions. 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) 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. *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 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.12
Alternative measures of portfolio response to attainment redesignations of ozone emitting firms.

Dep. variable:	Δ*Shares*		Δ*Traded value*	
	(1)	(2)	(3)	(4)
Redesig ratio$_t$	-0.002	-0.002	0.137	-0.093
	(-0.66)	(-0.49)	(0.78)	(-0.37)
Ozone ratio$_{t-1}$	-0.002	-0.002	0.169	-0.136
	(-1.30)	(-0.98)	(1.41)	(-0.59)
Redesig ratio$_t$ $\times$ *Ozone ratio*$_{t-1}$	0.018**	0.012*	1.555***	1.556***
	(2.29)	(1.77)	(4.30)	(3.18)
Stock controls	Yes	Yes	Yes	Yes
Fund controls	Yes	No	Yes	No
Fund $\times$ Stock F.E.	No	Yes	No	Yes
Fund $\times$ 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	398,004	372,756	373,808	293,765
Adj R^2	0.01	0.01	0.01	0.39

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 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) during the quarters after the attainment redesignation relative to the quarters before. The dependent variable in columns (3) and (4) is the change in 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 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 of ozone emitting firms in response to attainment redesignations, using toxicity-weighted emissions.

Dep. variable: Δw	(1)	(2)	(3)	(4)
Redesig ratio$_t$	0.020	0.013	0.024	0.016
	(1.49)	(0.92)	(1.59)	(0.99)
TW ozone ratio$_{t-1}$	0.019**	0.022**	0.019**	0.021**
	(2.51)	(2.47)	(2.34)	(2.19)
Redesig ratio$_t$ $\times$ *TW ozone ratio*$_{t-1}$	0.134***	0.163***	0.077***	0.090***
	(5.01)	(5.61)	(2.79)	(3.02)
Stock controls	Yes	Yes	Yes	Yes
Fund controls	Yes	Yes	No	No
Fund $\times$ Stock F.E.	No	Yes	No	Yes
Fund $\times$ Year-Quarter F.E.	No	No	Yes	Yes
Fund F.E.	Yes	No	No	No
Stock F.E.	Yes	No	Yes	No
Year-Quarter F.E.	Yes	Yes	No	No
Observations	373,808	305,932	364,474	293,765
Adj R^2	0.03	0.03	0.11	0.15

This table reports the regression estimates from Equation (3) at the fund-firm-quarter level using toxicity-weighted ozone emissions. 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) 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 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.14

Operating performance of ozone emitting firms around unexpected and anticipated nonattainment designations.

Dep. variable:	ROA_t		ROS_t		$Sales\ growth_t$	
	(1)	(2)	(3)	(4)	(5)	(6)
$Unexp.\ NA\ ratio_t$	0.002	0.001	-0.018	-0.028**	-0.033	-0.039
	(0.39)	(0.29)	(-1.28)	(-2.08)	(-1.19)	(-0.96)
$Antic.\ NA\ ratio_t$	-0.006**	-0.005*	-0.015	-0.013	0.002	-0.030
	(-2.51)	(-1.89)	(-1.26)	(-1.08)	(0.10)	(-1.11)
$Ozone\ ratio_{t-1}$	-0.001	-0.002	-0.013*	-0.014	-0.009	-0.039
	(-0.62)	(-0.79)	(-1.66)	(-1.55)	(-0.42)	(-1.60)
$Unexp.\ NA\ ratio_t \times Ozone\ ratio_{t-1}$	-0.001	-0.006	0.030	0.036	0.036	0.028
	(-0.10)	(-0.61)	(1.47)	(1.54)	(0.85)	(0.36)
$Antic.\ NA\ ratio_t \times Ozone\ ratio_{t-1}$	0.004	0.004	0.023	0.022	-0.039	0.043
	(0.86)	(0.69)	(1.04)	(0.88)	(-1.17)	(0.88)
$Unexp.\ NA\ ratio_t \times Ozone\ ratio_{t-1} \times Post_t$	-0.014**	-0.014**	-0.034**	-0.034**	-0.120**	-0.111**
	(-2.44)	(-2.43)	(-2.08)	(-2.07)	(-2.04)	(-2.03)
$Antic.\ NA\ ratio_t \times Ozone\ ratio_{t-1} \times Post_t$	0.003	0.003	-0.030	-0.031	0.023	0.035
	(0.62)	(0.62)	(-1.01)	(-1.03)	(0.58)	(0.82)
Stock controls	Yes	Yes	Yes	Yes	Yes	Yes
Stock × Industry F.E.	No	Yes	No	Yes	No	Yes
Industry × Year-Quarter F.E.	No	Yes	No	Yes	No	Yes
Stock F.E.	Yes	No	Yes	No	Yes	No
Industry F.E.	Yes	No	Yes	No	Yes	No
Year-Quarter F.E.	Yes	No	Yes	No	Yes	No
Observations	6,192	6,192	6,152	6,152	6,260	6,260
Adj R^2	0.62	0.62	0.52	0.51	0.06	0.13

This table reports the regression estimates from Equation (4) at the firm-quarter level decomposing nonattainment designations into unexpected and anticipated components. We focus on two quarters before to two quarters after the nonattainment designation. The dependent variable is *ROA* in columns (1) and (2), *ROS* in columns (3) and (4), and *Sales growth* in columns (5) and (6). *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* 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 IA.15
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.16

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

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)
$Post_t$	-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)
$NA\ ratio_t \times Underweight_t$	-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)
$NA\ ratio_t \times Post_t$	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)
$Underweight_t \times Post_t$	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)
$NA\ ratio_t \times Underweight_t \times Post_t$	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 (5) 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 (in pounds) 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* 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.17

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)
$Post_t$	-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)
$NA\ ratio_t \times Underweight_t$	-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)
$NA\ ratio_t \times Post_t$	-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)
$Underweight_t \times Post_t$	-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)
$NA\ ratio_t \times Underweight_t \times Post_t$	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 (5) 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 (in pounds) 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* 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.