The Green Reallocation Paradox: Do Capital Investments Abandon Polluting Industries?

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Abstract

The existing literature proposes various mechanisms to discipline corporate pollution, but do capital investments subsequently abandon polluting industries? We document a striking paradox. Contrary to expectations, external capital markets continue to allocate greater capital to stand-alone firms operating in highly polluting industries, without a corresponding increase in pollution abatement. In contrast, multisector firms reduce investment in their pollution-intensive peripheral segments, revealing substantial within-firm green reallocation. A difference-in-differences analysis exploiting environmental incidents as quasi-exogenous shocks confirms that this divergence is causal: environmental shocks activate within-firm capital reallocation but leave market-wide capital flows unchanged. Investigating the mechanisms underlying this divergence, we find that regulatory shocks (nonattainment status), environmental pressure, and financial constraints amplify internal reallocation but fail to trigger market-wide divestment from polluting industries, while the cost-of-capital channel plays no significant role. These empirical patterns are consistent with a simple model in which internal budget constraints translate compliance costs into reduced investment. Overall, our findings reveal a critical limitation of existing environmental disciplining mechanisms and identify internal capital markets—not external financial markets—as the central arena for real-sector environmental capital reallocation.

Keywords: Green reallocation paradox, capital allocation, real effects, pollution intensity, internal capital markets, financial constraints.

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1. Introduction

Environmental studies establish that polluting firms face mounting regulatory risks, heightened public scrutiny, increased cost of capital, and amplified reputational concerns.[1] A natural implication is that these mechanisms should discipline pollution by steering market-wide capital away from polluting industries and toward greener alternatives. However, recent studies indicate that external environmental pressures often lead to ownership reshuffling or geographic relocation (e.g., Berg, Ma, and Streitz 2024; Duchin, Gao, and Xu, 2025; Darmouni and Zhang, 2024; Bartram, Hou, and Kim, 2022; Hartzmark and Shue, 2024). These firm-level findings point to a critical gap in the literature and raise fundamental questions: Do existing environmental mechanisms actually drive industry-wide capital disinvestment, or do they merely shift the burden of pollution from one firm to another? And if so, what channels enable genuine green capital reallocation?

This paper provides new insights into these important questions by documenting a "green reallocation paradox." On the one hand, when we aggregate firms' capital expenditures to the industry level to mitigate cross-firm shifts, we find striking evidence that market-wide capital allocation tends to flow into, rather than out of, industries with high pollution intensity. On the other hand, this apparent failure of external markets motivates us to explore an alternate channel: internal capital markets within multisector firms (those operating subsidiaries across diverse industries). Our results suggest that this alternative allocation mechanism partially bridges the gap, serving as a pivotal driver of green capital reallocation.

The effectiveness of the internal channel rests on a sound economic rationale. Prior research demonstrates that internal capital markets enable firms to reallocate resources efficiently in

[1] Regulatory pressure, such as U.S. Clean Air Act nonattainment designations, is known to induce firms to reduce plant numbers, employment, and output in polluting industries (Henderson, 1995; Becker and Henderson, 2000; Berman and Bui, 2001; Greenstone, 2002). Firms with high pollution levels also face elevated costs of capital (Hsu, Li, and Tsou, 2023; Bolton and Kacperczyk, 2021; Gormsen, Huber, and Oh, 2024; Chava, 2014), enabling ESG investors and stakeholders to exert discipline against investments in high-pollution sectors or products (Bisetti, She, and Zaldokas, 2023; Oehmke and Opp, 2024; Landier and Lovo, 2025; Green and Roth, 2025). However, most existing analyses focus on firm-level evidence, which may be confounded by leakage—such as the transfer of polluting assets to less environmentally constrained investors or regions. In the presence of leakage, it remains unclear whether reduced investments by some firms will translate into aggregate reductions in the polluting industry.

response to productivity shocks or investment opportunities (e.g., Shin and Stulz, 1998; Giroud and Mueller, 2015). Extending this logic, if a firm's headquarters internalizes environmental considerations alongside financial metrics, the same internal mechanism may systematically redirect capital away from pollution-intensive segments. This provides a potent, within-firm avenue for environmental discipline that may operate more directly than the external market.

We analyze the green reallocation paradox using a comprehensive sample of U.S. public firms from 1990 to 2021. To contrast market-wide and within-firm capital flows, we integrate data from Compustat, the EPA's Toxics Release Inventory (TRI), and the National Establishment Time-Series (NETS) database. Our analysis is conducted at the 3-digit SIC (SIC3) level to capture meaningful industry-level shifts. To measure market-wide allocation, we aggregate capital expenditures and plant-level pollution (*Total Release*) for single-sector firms at the industry level. By focusing on single-sector firms, we obtain a clean measure of how the external market allocates capital across industries without the confounding influence of internal corporate transfers (though our results are robust to include all firms). To examine within-firm green reallocation, we rely on Compustat's segment-level capital expenditure data and aggregate TRI plant-level pollution to the corresponding industry segments. In both analyses, we measure industry pollution intensity as total sector-level pollution scaled by either employment or sales.

Our baseline analysis links sector-level capital expenditures to lagged pollution intensity. In market-wide tests, we find a positive and marginally significant relationship between the two, suggesting that contrary to the "divestment" narrative, capital continues to flow into high-polluting industries. When we replace capital expenditures with total net funding from equity and debt issuance, the relationship becomes even more positively significant, further confirming that external financial markets have not abandoned polluting sectors.

These observations are broadly consistent with the "green paradox" (Sinn, 2008), which posits that anticipated future environmental regulations can lead high-emission firms to preemptively accelerate contemporaneous investments in carbon-intensive assets. Our findings extend this literature in several dimensions. First, while the original green paradox focuses on carbon

emissions, we demonstrate that its underlying economic rationale applies equally to industrial pollution. Second, while much of the evidence on the green paradox (e.g., Albuquerque et al., 2025) focuses on firm-level responses to anticipated environmental policies, documenting higher emissions before policy implementation and lower emissions afterward, our analysis instead examines the persistent long-run pattern of capital allocation. Lastly, our results on net funding move beyond the traditional firm-centric incentives of the green paradox, suggesting that external investors and lenders may be subject to the same "paradoxical" incentives as the firms they finance.

In stark contrast, multisector firms systematically reduce capital expenditures in their most pollution-intensive segments. This internal reallocation effect is both statistically significant and economically substantial: a one-standard-deviation increase in a segment's pollution intensity is associated with a 3.5 basis point decrease in its subsequent capital expenditure (scaled by segment assets). For a typical firm-segment in our sample, this translates to an approximate reduction of $2.19 million in within-firm segment-level capital expenditures. These results indicate that multisector firms may internalize environmental considerations and, through their internal capital markets, achieve better green capital reallocation.

While the preceding tests demonstrate that investments diverge sharply across external and internal markets, a critical missing dimension is the role of compliance-related expenditures. If the capital flowing into polluting industries is primarily directed toward environmental compliance, such as installing abatement technologies to meet regulatory standards, then the "paradox" could merely reflect the high compliance cost of stand-alone firms. To examine this effect, we examine whether abatement intensity, defined as the ratio of abatement activities to assets and capturing firms' environmental compliance efforts, increases with industry pollution intensity. In market-wide tests, we insignificant relationship.[2] Conversely, as multisector firms divest from pollution-intensive segments, they also reduce abatement intensity in those segments. Together, these results indicate that external capital continues to flow into polluting industries without commensurate

[2] A caveat is that our abatement measure captures the count of abatement activities rather than their dollar value, which is unavailable in standard disclosures. To further alleviate this concern, we also use cross-sectional regressions to directly adjust capital expenditures by accounting for the potential impact of environmental abatement intensity. Our results confirm the divergence between market-wide and within-firm capital allocation.

abatement efforts, while internal capital markets simply reallocate resources away from pollution without "cleaning up" existing operations.

To establish a causal interpretation of the divergence, we exploit environmental incidents from the RepRisk database as quasi-exogenous shocks in a difference-in-differences (DID) framework. Following the identification strategy of Duchin, Gao, and Xu (2025), we use discrete and publicly observable events as shocks to firms' and industries' environmental risk profiles. The DID results reveal that environmental incidents activate within-firm capital reallocation away from pollution-intensive segments but leave market-wide capital flows essentially unchanged. Dynamic event study estimates confirm the parallel-trends assumption and show that the reallocation effect emerges sharply at the year of the incident and intensifies persistently over time. This quasi-experimental evidence supports a causal interpretation of the green reallocation paradox.

We then investigate the economic mechanisms that underlie this divergence. We first examine regulatory stringency by exploiting county transitions to nonattainment status under the Clean Air Act (Becker and Henderson, 2000; Greenstone, 2002; Walker, 2013, 2021; Greenstone et al., 2012; Shapiro and Walker, 2018; Curtis, 2020). We find that non-attainment events significantly amplify the negative relationship between pollution intensity and capital expenditure in within-firm tests, yet they have no such effect in market-wide tests. Notably, the incremental impact of these regulatory shocks is substantially larger than our baseline internal capital market efficiency, suggesting that regulatory pressure is a primary driver of internal green reallocation. Furthermore, non-attainment status fails to stimulate a market-wide increase in abatement intensity. Since internal capital markets appear to be more responsive to exogenous environmental regulatory shocks than external financial markets, this analysis lends support to a causal interpretation to the observed green reallocation paradox.[3]

After establishing the paradox, we next examine mechanisms traditionally thought to discipline polluting firms. We first investigate external environmental pressure from the public and investors, using proxies such as KLD environmental ratings, positive CSR scores, and pension

[3] Using the 2015 Paris Agreement as a regulatory shock leads to very similar conclusions.

fund holdings (Duchin, Gao, and Xu 2025). While heightened pressure significantly amplifies *within-firm* divestment from pollution-intensive segments, aggregate market-wide allocation remains largely unresponsive.

We then consider financial frictions, distinguishing between price-based channels (e.g., cost of capital) and quantity-based mechanisms (e.g., financial constraints). To explore their impact, we employ two proxies for the cost of capital: implied cost of capital (Easton, 2004) and perceived cost of capital (Gormsen and Huber, 2024). We complement these measures with two classical measures of financial constraints: the KZ Index (Kaplan and Zingales, 1997) and the WW Index (Whited and Wu, 2006). Our results reveal a striking distinction: higher costs of capital for polluting industries do not improve allocational efficiency in either market. Instead, internal green reallocation is primarily activated when firms face limited funding capacity. This suggests that environmental discipline is not a direct consequence of market pricing, but rather an internal rationing phenomenon triggered by financial constraints.

Given the pivotal role of multisector firms in resolving the paradox, we further delve into the organizational hierarchy and operational nature of their reallocation decisions. We find that capital flows out of polluting sectors primarily when they are operated by peripheral plants rather than "core" business units. This evidence indicates that headquarters manage environmental risk through targeted, strategic pruning: under pressure, firms protect their core industrial identity while sacrificing peripheral, high-pollution operations. Moreover, internal divestment is nuanced by the type of pollution involved, driven exclusively by toxic, on-site releases, rather than non-toxic waste or releases that can be easily outsourced to third-party treatment facilities. This suggests that headquarters prioritize mitigating visible toxic spills and adopt a divestment strategy to operationally manage "un-hedgeable" risks that cannot be easily outsourced.

These findings explain why multisector firms are uniquely capable of overcoming the green paradox. On one hand, since peripheral assets are less critical to the firm’s strategic center, the opportunity cost of divesting from them is significantly lower than for single-sector firms. Furthermore, internal reallocation can also be more effectively achieved because "internal" owners

(headquarters) possess greater monitoring and control rights over assets than the "external" owners of stand-alone firms (Gertner, Scharfstein, and Stein, 1994).

On the other hand, regulatory exposure, external pressures, and financial frictions also create opportunities for forward-looking asset restructuring. This aligns with the fundamental economic purpose of internal capital markets: to dynamically redirect resources in response to external shocks or shifting opportunities (Alchian, 1969; Williamson, 1975; Stein, 1997). Indeed, because asset restructuring requires time and planning, multisector firms that anticipate rising costs for peripheral polluting assets (e.g., from tightening regulations) can initiate divestment earlier, mitigating future constraints while preserving core value. This agility positions internal capital markets as a primary arena for proactive environmental risk management, offering a more responsive and informed mechanism than the frictions that limit external markets.

In Appendix B, we formalize the above intuition in a simple model comparing a stand-alone polluting firm with a two-sector firm that operates a productive core alongside a more polluting peripheral segment. Both firms invest over two periods under convex adjustment costs, but face a probability that environmental pressure will intensify in the second period, raising the cost of capital and compliance costs for polluting assets. We show that the stand-alone firm may front-load investment into the first period to exploit cheaper current financing, generating a green paradox. In contrast, an internal budget constraint within the two-sector firm forces sectors to compete for scarce capital: because the peripheral segment faces steeper compliance costs under environmental pressure, headquarters reallocates investment toward the core. This budget constraint, which is absent in external markets, absorbs the common financing-cost force that drives the green paradox and activates a differential compliance cost channel that triggers internal green reallocation. This simple framework echoes many of the empirical findings documented in our paper on the efficiency of internal green capital reallocation.

Having examined the potential mechanisms, we next employ alternative samples to address two pivotal economic questions. First, given that single- and multisector firms exhibit opposing effects on green reallocation, what is the net aggregate impact on the economy? Second, since the

sales of polluting plants (e.g., Duchin et al., 2025) may lead to reduced capital expenditure, could asset sales be the primary driver behind the results of multi-sector firms?

To explore these questions, we (i) expand the dataset to include both single- and multi-segment firms, and (ii) refine our sample by excluding firms that have undergone plant-sales events. When considering market-wide green reallocation across all firms, the results yield an insignificantly negative coefficient. This suggests that the efficiency gains achieved by multi-sector firms are currently insufficient to fully offset the inefficiencies present in the external market. Furthermore, excluding divestment events does not affect internal green reallocation, indicating that our findings may reflect a novel internal-market mechanism unidentified in previous studies. Additionally, we also demonstrate that our results are robust to alternative investment specifications and various subsample partitions.

Collectively, our findings suggest that green reallocation is more effectively achieved through internal rather than external capital markets. This suggests that despite the well-documented disadvantages of multisector firms (most notably the conglomerate discount; e.g., Berger and Ofek, 1995; Rajan, Servaes, and Zingales, 2000)[4], the internal corporate structure may nonetheless serve as a critical, and perhaps underappreciated, determinant of how the real economy adapts to the challenges of climate change and environmental regulation. While external financial markets may remain sluggish or conflicted in their response to pollution, the internal capital market and organizational structure of multisector firms provide a vital mechanism for the intended green transition.

Our findings contribute to several strands of literature. A central premise of green finance is that regulatory risk (Becker and Henderson, 2000; Greenstone, 2002; Li and Wang, 2025), environmental scrutiny (Oehmke and Opp, 2024; Landier and Lovo, 2025), cost of capital (Bolton and Kacperczyk, 2021; Hsu, Li, and Tsou, 2023; Gormsen, Huber, and Oh, 2024), and reputational concerns (Bisetti, She, and Zaldokas, 2023) should incentivize firms to divest from polluting assets, increase abatement, or both. In theory, for instance, investors' green preferences should raise the

[4] Note that such discounts may arise under optimal internal capital allocation and profit-maximizing behavior (e.g., Maksimovic and Phillips, 2002).

cost of capital for brown firms, thereby reducing their investments and firm size (Pástor, Stambaugh, and Taylor 2021). Our industry-level analysis, however, demonstrates the limits of these mechanisms. To our knowledge, we are the first to directly compare environmental capital allocation across external and internal markets, documenting a green reallocation paradox that identifies the true locus of environmental capital efficiency.

Our results also extend a burgeoning strand of literature investigating the real impact of environmental mechanism. Starks (2023) and Hartzmark and Shue (2024) argue that even when sustainable investing alters firms' financing conditions, real investment responses may be muted due to re-ownership and weak impact elasticities. Berg, Ma, and Streitz (2024), Duchin, Gao, and Xu (2025) and Darmouni and Zhang (2024) document the sale of polluting plants to less constrained private owners. Bartram, Hou, and Kim (2022) show that California's cap-and-trade program led constrained firms to shift emissions across state lines, leaving firm-wide pollution unchanged. Albuquerque et al., (2025) demonstrate that anticipated future environmental regulations can lead polluting firms to accelerate contemporaneous investments in polluting assets, aligning with a financing channel of the green paradox (Sinn, 2008).

We differ from these studies in two important respects. First, by testing market-wide cross-industry capital allocation, we capture equilibrium real outcomes rather than partial reallocations among firms. Second, we identify internal capital markets, not external financial markets, as the primary margin through which polluting activities are disciplined. This shifts the focus from external markets to internal capital markets in driving genuine green reallocation.

We also extend the internal capital market literature by showing that reallocation responds not only to productivity shocks but also to environmental risk shocks. The efficient internal capital markets hypothesis (Alchian, 1969; Williamson, 1975; Stein, 1997) posits that headquarters create value by actively reallocating scarce resources across divisions. Shin and Stulz (1998) show that segment investment depends on the cash flows of other divisions, while Giroud and Mueller (2015) provide causal evidence that financially constrained firms reallocate capital and labor toward higher-return plants. We extend this framework to environmental risk. When external markets fail,

internal capital markets may function as a mini social planner that reallocates capital away from environmentally risky activities. Environmental risk thus constitutes a novel and economically important shock to internal capital allocation, analogous to the productivity shocks at the core of traditional literature.

Our results also have important normative implications. Current ESG disclosures focus on firm-wide aggregates, which allow for external re-ownership and leakage. To drive real-sector change, regulators should mandate segment-level environmental reporting, as the internal capital market is where the most meaningful reallocation is already occurring.

The remainder of the paper proceeds as follows. Section 2 describes the data sources and variable construction. Section 3 presents empirical baseline results. Section 4 shows the capital reallocation under exogenous regulatory and environmental shocks. Section 5 presents the economic analysis, and Section 6 concludes.

2. Data and Main Variables

Our sample is compiled from the plants operated by US public manufacturing firms over the 1990-2021 period. We will describe each data source, sample size and variable construction below. Appendix A shows the detailed variable definition and Table 1 reports the summary statistics.

2.1 Data and sample

We collect data from several comprehensive sources to construct our plant-, segment-firm-, industry-level measures. Plant-level toxic releases measures are obtained from the EPA's Toxics Release Inventory (TRI) program, which provides polluting plant identifiers, chemical identification information, and annual quantities of each chemical released on-site and transferred off-site. To identify chemicals harmful to humans and construct the variable about toxic releases, we match TRI data with the EPA's Integrated Risk Information System (IRIS) using Chemical Abstract Services (CAS) numbers. We further utilize the EPA's Pollution Prevention (P2) database to examine abatement activities, where facilities reporting to TRI are required to document, at the chemical level, source reduction activities that limit the number of hazardous substances entering the waste stream. Plant-level financial data are drawn from the National Establishment Time-Series

(NETS) database, provided by Dun and Bradstreet (D&B) and maintained by Walls and Associates. NETS links directly to EPA plants through DUNS numbers and TRI identifiers, allowing us to obtain variables such as sales, employment, and Paydex scores. LSEG Dun & Bradstreet (D&B) provide the link between DUNS and other firm ID such as CUSIP and ISIN, that enable us to find the Compustat fundamental data for plants' parent firms.

We obtain ESG ratings for U.S. public firms from the KLD database. KLD evaluates each firm across six categories: Community, Diversity, Employee Relations, Environment, Human Rights, and Product. For each category, it reports the number of strengths and concerns. We employ the ESG incidents data from RepRisk which provide the complete firm-level environmental, social, and governance incidents data.

Following Rajan, Servaes, and Zingales (2000), Peyer and Shivdasani (2001), Ahn and Denis (2004), and Giroud and Mueller (2015), we use SIC3 segment-level data to analyze the functioning of internal capital markets and the efficiency of within-firm capital allocation. In our sample, we aggregate the plant-level data to within-firm across 3-digit SIC3 industry-level data to examine the within-firm across-industry allocation. We obtain the within firm across 3-digit industry financial data from Compustat segment data, which provide assets and capital expenditures etc. As is standard practice, we cross-validate observations in the segment data with those in the Compustat firm annual fundamental data and exclude observations for which the sum of reported segment sales deviates by more than 25% from total firm sales in the annual files. Following Xuan (2009), Berger and Ofek (1995), and Billett and Mauer (2003), we adjust the segment-level data to ensure consistency with the firm-level data. Specifically, we measure the deviation between the sum of segment-level data items (assets, sales, capital expenditures, operating income, and depreciation) and their corresponding firm-level values, and then prorate the unallocated amount across segments accordingly[5].

[5] For example, if the sum of segment capital expenditures is 5% lower than the total capital expenditures reported at the firm level, the capital expenditures of each segment are grossed up by 5%. Specifically, the adjusted capital expenditures for a segment are calculated as the unadjusted capital expenditures for that segment multiplied by the ratio of firm-level capital expenditures to the sum of all segment capital expenditures.

Finally, for the analysis of within-firm across-industry allocation, we have a sample of 532 multi-segment manufacturing firms (with 3 segments on average) across 109 3-digit SIC industries from 1990 to 2021. For the analysis of market-wide industry allocation, we aggregate the plant-level data to 3-digit SIC3 industry-level data and obtain a sample of 94 3-digit SIC manufacturing industries of single-segment firms.

2.2 Variable construction

Following Xuan (2009) and Scharfstein (2010), we construct the key measure of within-firm capital allocation, that is the capital expenditure divided by total assets within-firm across 3-digit industries, and multiply by 100. We also construct three alternative measures for robustness checks: *Capex/Beginning of Year Assets, Log (Capex/ assets), and Capex / Sales*. *Capex/Beginning of Year Assets* is defined as capital expenditure divided by the beginning of year assets (i.e., Assets minus Capex and plus depreciation) and multiply by 100. *Log (Capex/ assets)* equals the logarithm value of capital expenditure to total assets and multiply by 100. *Capex / Sales* is defined as capital expenditure divided by sales and multiply by 100.

For the examination of market-wide allocation, we employ the *Net Total Funding Rate* and *Capex to Assets* ratio as the main proxies for industry-level capital allocation. The *Net Total Funding Rate* of an industry is the sum of all equity and debt funds raised by the industry's firms during the year, divided by the sum of the total assets of the firms in the industry at the start of the year (Lee, Shin and Stulz. 2021). Equity funding during a year is computed as the sale of common stock and preferred stock minus the purchase of common and preferred stock. Debt funding is the issuance of long-term debt minus the reduction in long-term debt plus the change in short-term debt. The industry-level *Capex to Assets* ratio is the value-weighted aggregation from 3-digit industries of plants-level.

We have two measures for pollution intensity, *Total Release/Employment* and *Total Release/Sales. Total Release/Employment* is defined as plant-level Total Release (pound) divided by number of employees, while *Total Release/Sales* is defined as plant-level Total Release (pound) divided by Sales. Both pollution intensity measures are aggregated from plants level to within-

firm across-industry level. *Total Release* is the sum of on-site and off-site releases. On-site releases refer to emissions or waste disposals that occur directly at the reporting facility, whereas off-site releases refer to waste that is transferred to another facility and ultimately released or disposed of there. Our toxic emissions measure, *Toxic Release*, is defined as a plant's total quantity of releases of all identified harmful chemicals. In order to examine which pollution source enhances the effect of within-firm capital allocation, we decompose Total release as *Toxic Releases, Non-toxic Releases, Onsite Toxic Releases* and *Offsite Toxic Releases,* to construct the corresponding pollution intensities.

The *Abatement* is defined as the number of source reduction activities that limit the number of hazardous substances entering the waste stream. We follow Akey and Appel (2021) to construct two categories of abatement activities: operating-related abatement and process-related abatement. Operating-related abatement represents the most common abatement activities include improved maintenance scheduling, record keeping, or procedures. Process-related abatement is the second most common type of abatement activities that comprise actions such as modifications to equipment, layout, or piping. We sum the plant level abatement to within-firm across 3-digit SIC industry measures*: All abatement, Process Abatement, Operating Abatement*.

2.3. Summary Statistics

Table 1 reports summary statistics for the key variables at the within-firm segment level (Panel A) and the industry level (Panel B) over the sample period 1990–2021.

At the segment level, the average Capex/Assets is 4.78%, with a median of 3.81%, indicating substantial heterogeneity in investment intensity across segments within the same firm. The right tail is large (95th percentile = 11.79%), suggesting that firms concentrate capital in selected segments rather than spreading investment evenly. At the industry level, Capex/Assets averages 4.75%, very close to the segment-level mean, but dispersion is lower. This contrast is consistent with our setting: within-firm allocation reflects active redistribution across segments, while industry aggregates these differences. The Net Total Funding Rate has a mean of 0.52% but large dispersion, including negative values, indicating that industries frequently experience net capital

withdrawals. Importantly, this variable captures external market funding, which we contrast with internal capital allocation.

Pollution intensity exhibits extreme skewness, consistent with the TRI distribution. At the segment level, Total Release/Employees has a mean of 1,629 pounds per worker but a median of only 41.6, indicating that most segments emit little pollution while a small number of heavy emitters drive the average. A similar pattern appears for Toxic Releases, confirming that environmental risk is highly concentrated.

Segment-level Abatement/Assets (number of source-reduction activities per assets) has a mean of 11.25 but a median of zero. This indicates that most segments report no abatement activities in a given year, while a small subset undertakes substantial mitigation efforts. This distribution supports our interpretation that abatement is lumpy and regulation-driven, rather than smoothly adjusting with output. Industry-level abatement intensity is lower on average, reflecting aggregation and dilution across firms.

3. Baseline analysis

This section provides our baseline evidence on how pollution intensity relates to real allocation decisions in external capital markets and inside multi-segment firms. Our central question is whether environmentally harmful activities are disciplined through capital reallocation, and if so, whether this discipline occurs through market-wide financing channels or through firms' internal capital markets. By examining both capital expenditures and abatement activities, we can distinguish between reductions in polluting production and changes in compliance behavior.

3.1 Market-wide vs. within-firm capital allocation

In this section, we begin by analyzing capital allocation. If external financial markets price environmental risk effectively, more pollution-intensive industries should experience lower funding and reduced investment. At the same time, if headquarters internalize regulatory exposure and compliance risk, internal capital markets may reallocate investment away from pollution-intensive segments even when external markets do not. To distinguish between these mechanisms,

we estimate parallel regressions at the industry level and at the within-firm segment level, allowing us to compare market-wide and internal capital allocation responses to pollution intensity. The baseline regressions are as follows:

$$Investment_{j,t} = a_0 + a_1 \times Pollution_{j,t-1} + A \times X_{j,t-1} + \varepsilon_{j,t} \qquad (1a)$$

Equation (1a) represents the market-wide capital allocation to pollution. Where $Investment_{j,t}$ denotes the ratio of net total funding (equity and debt) to assets and the ratio of capital expenditure to assets for industry j in year t, $Pollution_{j,t-1}$ is the industry pollution intensity of the previous year, and the vector $X_{j,t-1}$ is a set of industry-level control variables, including Tobin's Q, Cash Flow, and Sales Growth. The industry-level variables are value-weighted aggregates from 3-digit industries of plants-level.

$$Investment_{i,\mathrm{j},t} = \beta_0 + \beta_1 \times Pollution_{i,\mathrm{j},t-1} + A \times X_{i,t-1} + \varepsilon_{i,t} \qquad (1b)$$

Equation (1b) represents the within-firm capital allocation to pollution. Where $Investment_{i,j,t}$ denotes the ratio of capital expenditure to assets for firm i's allocation to industry j in year t, $Pollution_{i,j,t-1}$is the pollution intensity of firm i's allocation to industry j in year $t-1$, and the vector $X_{i,t-1}$ is a set of firm-level control variables, including Tobin's Q, Cash Flow, and Sales Growth. For easier interpretation, all key explanatory variables are standardized to have mean zero and unit standard deviation throughout tables.

Table 2 contrasts how pollution intensity shapes capital allocation in external capital markets versus within multi-segment firms. Models (1) and (2) examine industry-level net external funding among single-segment firms. Pollution intensity is positively and statistically significantly associated with net funding. A one-standard-deviation increase in industry pollution intensity corresponds to a 0.71–0.52 increase in the net funding rate, indicating that pollution-intensive industries do not face tighter external financing conditions. If anything, these industries obtain more, rather than less, external capital.

Models (3) and (4) report industry-level investment outcomes. Pollution intensity is again positively related to capital expenditures, with coefficients of 0.22 and 0.20 that are statistically significant at conventional levels. This pattern suggests that market-wide capital flows continue to finance real investment in pollution-intensive industries. Taken together, the results in Models (1)

to (4) indicate that external capital markets do not discipline pollution exposure through reduced funding or lower industry-level investment.

In contrast, Models (5) and (6) examine within-firm capital allocation across segments of multi-segment firms. Here the relationship reverses sign. Segment-level pollution intensity is negatively and significantly related to segment CAPEX/Assets. A one-standard-deviation increase in segment pollution intensity reduces the segment investment ratio by 0.035–0.030 percentage points. Using the average segment asset size of 6,249.12 million USD, this translates into a reduction of approximately $2.19 million in segment-level capital expenditure. Because these specifications include firm, segment-industry, and year fixed effects, the estimates reflect how headquarters reallocate capital across segments within the same firm.

These findings reveal a sharp divergence between external and internal capital allocation. At the market level, pollution-intensive industries continue to attract both financing and investment. Within firms, however, headquarters systematically channel capital away from more pollution-intensive segments. The contrast suggests that internal capital markets play a more active role than external markets in incorporating environmental risk into capital allocation decisions.

3.2 Market-wide vs. within-firm abatement allocation

We then turn to environmental abatement. Unlike productive capital investment, abatement allocation is directly tied to regulatory compliance and legal liability. If firms respond to environmental pressure primarily through compliance channels, pollution intensity should be associated with higher abatement efforts. Conversely, if firms instead adjust the scale of polluting production while maintaining required compliance, abatement allocation may remain stable even as productive investment is reallocated. The baseline regressions are as follows:

$$Abatement_{j,t} = a_0 + a_1 \times Pollution_{j,t-1} + A \times X_{j,t-1} + \varepsilon_{j,t} \qquad (2a)$$

Equation (2a) represents the market-wide abatement allocation to pollution. Where $Abatement_{j,t}$ denotes the ratio of abatement activity to sales for industry j in year t, $Pollution_{j,t-1}$ is the industry pollution intensity of the previous year, and the vector $X_{j,t-1}$ is a set of industry-level control variables, including Tobin's Q, Cash Flow, and Sales Growth. The industry-level variables are value-weighted aggregates from 3-digit industries of plants-level.

$$Abatement_{i,j,t} = \beta_0 + \beta_1 \times Pollution_{i,j,t-1} + A \times X_{i,t-1} + \varepsilon_{i,t} \qquad (2b)$$

Equation (2b) represents the within-firm abatement allocation to pollution. Where $Abatement_{j,t}$ denotes the ratio of abatement activity to sales for firm i's allocation to industry j in year t, $Pollution_{i,j,t-1}$ is the pollution intensity of firm i's allocation to industry j in year $t-1$. Pollution intensity is defined as total releases divided by employment, and total releases divided by sales, and both measures are standardized by standard errors in the regressions. The vector $X_{i,t-1}$ is a set of firm-level control variables, including Tobin's Q, Cash Flow, and Sales Growth.

Table 3 examines how pollution intensity relates to the allocation of environmental abatement expenditures. The dependent variable is abatement expenditures scaled by segment assets, which captures the intensity of compliance-related environmental investment. Models (1) and (2) report market-level results using single-segment firms. In these specifications, pollution intensity is not significantly associated with abatement intensity. This indicates that external capital markets do not induce pollution-intensive industries to increase environmental abatement spending, nor do they appear to restrict such expenditures. In other words, abatement effort at the industry level is largely insensitive to pollution exposure from the perspective of market-wide financing conditions.

In contrast, Models (3) and (4) focus on within-firm allocation across segments in multi-segment firms. Here, pollution intensity is negatively and significantly related to segment-level abatement intensity. A one–standard-deviation increase in segment pollution intensity is associated with a 0.18–0.20 percentage point reduction in abatement expenditures relative to segment assets. Because these regressions include firm, segment-industry, and year fixed effects, the estimates reflect internal reallocation decisions by headquarters across segments within the same firm. The results suggest that headquarters reduce both productive investment (Table 2) and abatement intensity in more pollution-intensive segments.

This pattern is consistent with the institutional nature of environmental abatement. Abatement spending is typically driven by regulatory compliance requirements rather than discretionary investment considerations. Once firms meet binding environmental standards, additional abatement may yield diminishing marginal benefits relative to its costs. Consequently, internal capital markets appear to respond to environmental risk primarily by scaling down pollution-intensive operations, rather than by intensifying end-of-pipe abatement activities in those segments.

Taken together, Tables 2 and 3 reveal a clear asymmetry in how environmental risk shapes corporate resource allocation. External capital markets continue to provide funding and support investment in pollution-intensive industries, and they do not induce greater abatement intensity. Within firms, however, headquarters systematically reallocate capital away from more pollution-intensive segments and also reduce abatement intensity in those segments. These findings suggest that environmental discipline operates primarily through internal restructuring of production scale, rather than through market-wide financing constraints or expanded compliance spending. Firms appear to manage environmental exposure by contracting pollution-intensive operations, instead of increasing abatement effort per unit of capital.

4. Capital investments under exogenous environmental shocks

To sharpen identification, we exploit environmental incidents as quasi-exogenous shocks to both industries' and firms' environmental risk exposure. Following the identification strategy of Duchin, Gao, and Xu (2025), we use environmental risk incidents from the RepRisk database to construct a difference-in-differences (DID) framework. We focus on environmental incidents, which capture events such as pollution violations, environmental lawsuits, toxic spills, and regulatory enforcement actions. These incidents represent discrete, publicly observable shocks that are plausibly exogenous to individual firms' and industries' capital allocation decisions. They serve as a natural treatment in a DID framework for both market-wide and within-firm analyses: at the industry level, an incident raises the environmental risk profile of the entire industry; at the firm level, it directly exposes the firm's headquarters to heightened reputational and regulatory pressure, potentially triggering internal reallocation across its segments.

4.1 Identification Strategy

We define treatment separately for each level of analysis. For the market-wide test, treatment is defined at the 3-digit SIC industry level: an industry is classified as treated if any firm operating in that industry recorded at least one environmental incident during the sample period, with the treatment year defined as the earliest incident year. Industries that never experienced an incident serve as controls. For the within-firm test, treatment is defined at the firm level: a firm is treated if it experienced at least one environmental incident, with the treatment year defined as the earliest

incident year for that firm. Firms that never experienced an incident serve as controls. In both cases, the design follows a staggered DID framework, where different industries (or firms) receive treatment at different times. The key treatment variable, Post, is an indicator equal to one for all industry-years (or segment-years) following the first environmental incident, and zero otherwise.

For the market-wide test, the unit of observation is a 3-digit SIC industry-year, constructed from single-sector firms aggregated to the industry level. The sample covers 94 SIC3 manufacturing industries (SIC 200–399), with 36 treated industries and 58 never-treated control industries, yielding 1,682 industry-year observations. The DID specifications are as follows:

$$Investment_{j,t} = a_0 + a_1 \times Pollution_{j,t-1} \times Post_{j,t} + a_2 \times Pollution_{j,t-1} + a_3 \times Post_{j,t} + A \times X_{j,t-1} + \varepsilon_{j,t} \quad (3a)$$

Equation (3a) examines the market-wide DID. Investment denotes industry-level Capex/Assets for industry j in year t. Pollution is Release/Employees (standardized). Post equals one after the industry's first environmental incident. X is a vector of industry-level controls (Tobin's Q, Cash Flow, Sales Growth). Industry and year fixed effects are included.

For the within-firm test, the unit of observation is a segment-year within multi-segment manufacturing firms. Treatment is defined at the firm level: a firm is treated if it experienced at least one environmental incident. The sample consists of 167 treated firms and 497 never-treated control firms, yielding 8,476 segment-year observations. The DID specifications are as follows:

$$Investment_{i,j,t} = \beta_0 + \beta_1 \times Pollution_{i,j,t-1} \times Post_{i,j,t} + \beta_2 \times Pollution_{i,j,t-1} + \beta_3 \times Post_{i,j,t} + A \times X_{i,t-1} + \varepsilon_{i,t} \quad (3b)$$

Equation (3b) examines the within-firm DID. Investment denotes segment-level Capex/Assets (×100) for firm i's segment in industry j in year t. Pollution is the segment's Release/Employees (standardized). Post equals one after the firm's first environmental incident. X is a vector of firm-level controls. Firm, segment industry (SIC3), and year fixed effects are included.

4.2 Main DID Results

Table 4 Panel A reports the main DID estimates comparing market-wide and within-firm capital allocation responses to environmental incidents. Models (1) and (2) present market-wide industry-level results; Models (3) and (4) present within-firm segment-level results. Models (1) and (3) include controls (Tobin's Q, Cash Flow, Sales Growth); Models (2) and (4) exclude controls.

At the market-wide level, the coefficient on Pollution × Post is economically small and statistically insignificant across both specifications. Environmental incidents do not trigger differential capital withdrawal from pollution-intensive industries. The standalone Pollution coefficient is marginally positive, consistent with the green paradox documented in our baseline analysis: more polluting industries continue to attract greater capital investment even after environmental shocks.

In contrast, the within-firm results reveal a sharply different pattern. The coefficient on Pollution × Post is −0.968 with controls and −1.263 without controls, both are statistically significant. After an environmental incident, firms disproportionately cut capital expenditure in their more pollution-intensive segments. The magnitude is economically meaningful: using the specification with controls, a one-standard-deviation increase in segment pollution intensity is associated with a 0.968 percentage point reduction in the Capex/Assets ratio following an environmental incident.

The contrast between market-wide and within-firm responses is striking. Industry-level capital allocation is completely unresponsive to the interaction of pollution intensity and environmental incidents, while within-firm segment-level effects are significant at conventional levels. This pattern reinforces the central finding of our baseline analysis: environmental shocks trigger internal capital reallocation away from pollution-intensive segments, but they fail to induce market-wide divestment from polluting industries.

4.3 Dynamic Effects

To validate the parallel-trends assumption and examine the dynamic path of the treatment effect, we estimate event study regressions that trace the interaction of Pollution × Event-Time over a seven-year window (−3 to +3 years around the first environmental incident, with t = −1 as the base period). Never-treated industries (or firms) serve as controls. The specification is:

$$Investment_{i,j,t} = b_0 + \sum_{-3}^{+3} b_\tau \times Pollution_{i,j,t-1} * Event(\tau) + b_7 \times Pollution_{i,j,t-1} + b_8 \times Event\ [-3,+3]_, + A \times X_{i,t-1} + \varepsilon_{i,t} \qquad (4)$$

where $Investment_{i,j,t}$ denotes the ratio of capital expenditure to assets for firm i's allocation to industry j in year t, $Pollution_{i,j,t-1}$ is the pollution intensity (Total releases/Employment) of firm i's allocation to industry j in year $t-1$, $Event(\tau)$ is a dummy equal to one if year t falls τ years relative to an environmental incident reported by RepRisk. *Event [-3, +3]* is an indicator for the event window. The vector $X_{i,t-1}$ is a set of firm-level control variables, including Tobin's Q, Cash Flow, and Sales Growth.

Table 4 Panel B reports the event study estimates on within-firm capital allocation. The pre-event coefficients at t = −3 and t = −2 are statistically insignificant, supporting the parallel-trends assumption. Post-event coefficients turn sharply negative and grow monotonically in magnitude. The reallocation effect is persistent and intensifying over time. Panel C plots the event study estimates on within-firm capital allocation with 90% confidence intervals. This figure displays a clear structural break at the incident year: pre-event coefficients hover around zero, while post-event coefficients decline sharply and persistently.

Taken together, the DID and dynamic effect results provide quasi-experimental evidence that environmental incidents—discrete, publicly observable shocks to firms' environmental risk profiles—activate internal capital reallocation but leave market-wide capital flows essentially unchanged. This finding is consistent with the identification strategy of Duchin, Gao, and Xu (2025), who use similar RepRisk incidents to study plant-level ownership changes. While Duchin et al. document that environmental incidents lead to ownership reshuffling of polluting plants, our analysis extends this framework to show that the same shocks also trigger within-firm capital reallocation across segments—but critically, without any corresponding market-wide capital withdrawal from polluting industries.

5. Additional economic analysis

In this section, we investigate the economic mechanisms that underlie this divergence. We examine four channels that may differentially shape how market-wide and within-firm investment responds to pollution exposure: regulatory stringency, that captured by county transitions to nonattainment status under the Clean Air Act; environmental pressure from ESG visibility, stakeholder monitoring, and institutional ownership; the cost of capital; and financial constraints. Beyond these channels, we explore heterogeneity in the reallocation response by examining which segments inside the firm are primarily affected and which categories of pollution drive the effect. Finally, we assess robustness using alternative samples and a comprehensive set of alternative measures and specifications.

From section 5.1 to 5.4, we test four channels and the *Indicator* represents regulatory stringency, environmental pressure, cost of capital, and financial constraint respectively. We adopt the same specifications as follows:

$$Investment_{j,t} = a_0 + a_1 \times Pollution_{j,t-1} \times Indicator_{j,t-1} + a_2 \times Pollution_{j,t-1} + a_3 \times Indicator_{j,t-1} + A \times X_{j,t-1} + \varepsilon_{j,t} \quad (5a)$$

Equation (5a) examines the impact on market-wide capital allocation. Where $Investment_{j,t}$ denotes the ratio of capital expenditure to assets for industry j in year t, $Pollution_{j,t-1}$ is the industry pollution intensity of the previous year, and the vector $X_{j,t-1}$ is a set of industry-level control variables, including Tobin's Q, Cash Flow, and Sales Growth. The industry-level variables are value-weighted aggregates from 3-digit industries of plants-level.

$$Investment_{i,j,t} = \beta_0 + \beta_1 \times Pollution_{i,j,t-1} \times Indicator_{i,j,t-1} + \beta_2 \times Pollution_{i,j,t-1} + \beta_3 \times Indicator_{i,j,t-1} + A \times X_{i,t-1} + \varepsilon_{i,t} \quad (5b)$$

Equation (5b) examines the impact on within-firm capital allocation. Where $Investment_{i,j,t}$ denotes the ratio of capital expenditure to assets for firm i's allocation to industry j in year t, $Pollution_{i,j,t-1}$is the pollution intensity of firm i's allocation to industry j in year $t-1$, and the vector $X_{i,t-1}$ is a set of firm-level control variables, including Tobin's Q, Cash Flow, and Sales Growth.

5.1 Regulatory stringency

We first examine how regulatory stringency shapes the relationship between pollution intensity and capital allocation at both the market-wide and within-firm levels. We exploit county transitions from attainment to nonattainment status under the U.S. Clean Air Act (CAA) as a source of variation in regulatory stringency. Under the CAA, counties are periodically classified as either *attainment* or *nonattainment* with respect to federally regulated air quality standards for criteria pollutants such as ozone. A county is designated as nonattainment if ambient pollution concentrations exceed the National Ambient Air Quality Standards (NAAQS), triggering a set of legally binding regulatory requirements that apply to all pollution-emitting facilities operating within the county.

Nonattainment designations represent a sharp increase in local regulatory stringency. Firms operating plants in nonattainment counties become subject to a broad set of command-and-control regulations aimed at reducing emissions, including tighter emission limits, technology mandates, and permitting requirements, often without regard to compliance costs (Becker and Henderson, 2000; Greenstone, 2002; Walker, 2021). These requirements are economically meaningful: evidence from the Pollution Abatement Costs and Expenditures (PACE) Survey indicates that Clean Air Act regulations account for roughly $5 billion in annual capital expenditures and $20 billion in operating costs in U.S. manufacturing alone, underscoring the substantial financial burden associated with regulatory compliance (U.S. Census Bureau; Walker). Manufacturers frequently argue that such regulatory costs place plants and industries at a competitive disadvantage, potentially leading to downsizing or plant closures. In contrast, facilities located in attainment counties face lighter regulatory oversight. Importantly, these regulatory obligations are imposed at the county level and apply uniformly to all covered facilities, regardless of firm characteristics or past compliance behavior.

Large literature exploits transitions from attainment to nonattainment status as quasi-experimental regulatory shocks to study the effects of environmental regulation on firm behavior,

labor reallocation, plant entry and exit, and productivity (Becker and Henderson, 2000; Greenstone, 2002, 2003; Walker, 2013, 2021; Greenstone et al., 2012; Shapiro and Walker, 2018; Curtis, 2020).

Consistent with this literature, we define *NA Switch* as an indicator equal to one if a segment's plants are located in counties that transition from attainment to nonattainment status in year *t*, and zero otherwise. We empirically test how the transition from attainment to nonattainment shapes the relationship between pollution intensity and capital allocation.

Table 5 Panel A presents how the *NA Switch* modifies the relation between pollution intensity and capital allocation. For market-wide capital allocation, Models (1) and (2) show that the interaction between pollution intensity and the *NA Switch* is positive and highly significant. Industries with higher pollution intensity experience higher, not lower, capital expenditures following the regulatory shock. A one–standard-deviation increase in pollution intensity raises the CAPEX-to-assets ratio by 0.068–0.095 percentage points after nonattainment designation. This indicates that external capital markets do not withdraw funding from pollution-intensive industries when regulation tightens. Instead, these industries appear to receive additional capital. The coefficient on NA Switch itself is negative and significant, suggesting that nonattainment designation is associated with a broad contraction in industry-level investment. This is consistent with prior evidence that stricter environmental regulation reduces aggregate economic activity in regulated areas (Greenstone, 2002; Becker and Henderson, 2000; Walker, 2013). However, the positive interaction term shows that this contraction is not concentrated among the most polluting industries.

In contrast, the within-firm results reveal the opposite pattern. In Models (3) and (4), the interaction between pollution intensity and NA Switch is negative and highly significant. Following nonattainment designation, firms reallocate capital away from more pollution-intensive segments toward cleaner segments within the same firm. A one-standard-deviation increase in segment pollution intensity reduces segment CAPEX-to-assets by 0.716–0.853 percentage points after the regulatory shock. Relative to the sample mean investment rate of 4.78%, this corresponds to a 15–18% decline in investment. This magnitude is substantially larger than in the baseline

analysis, indicating that regulatory pressure sharply amplifies internal capital reallocation. Importantly, the coefficient on *NA Switch* itself is negative and significant in the within-firm specifications, but the magnitude of the interaction term implies that the shock primarily operates through within-firm reallocation, rather than through uniform firm-wide investment cuts.

Table 5 Panel A highlights a stark divergence between market-wide and internal capital allocation responses to regulatory shock. While aggregate investment declines following nonattainment designation, capital flows toward pollution-intensive industries at the market level but away from pollution-intensive segments within firms.

Table 5 Panel B reports how the regulatory shock affects environmental abatement activities. At the market level (Models 1–2), the interaction between pollution intensity and *NA Switch* is negative and strongly significant. Pollution-intensive industries reduce abatement activities after nonattainment designation. This suggests that external markets do not promote greater environmental effort in response to stricter regulations. Within firms, however (Models 3–4), the interaction terms are statistically insignificant. Instead, the main effect of pollution intensity is negative and significant, indicating that more pollution-intensive segments already exhibit lower abatement intensity, but this does not change materially after the regulatory shock. In other words, the regulatory shock primarily alters capital allocation, not abatement spending.

Taken together, we find that non-attainment events significantly amplify the negative relationship between pollution intensity and capital expenditure in within-firm tests, yet they have no such effect in market-wide tests. Notably, the incremental impact of these regulatory shocks is substantially larger than our baseline internal capital market efficiency, suggesting that regulatory pressure is a primary driver of internal green reallocation. Furthermore, non-attainment status fails to stimulate a market-wide increase in abatement intensity. Collectively, these results reinforce the conclusion that internal capital markets are far more responsive to environmental regulatory shocks than external financial markets, which appear largely indifferent to these local escalations in compliance risk.

5.2 Environmental pressure

We next examine how environmental pressure arising from public scrutiny and stakeholder monitoring differentially shapes market-wide and within-firm capital allocation. These shocks arise from increases in public attention that raise the expected costs of environmentally harmful activities through reputational and financing channels.

Following Duchin, Gao, and Xu (2025), we construct a series of proxies for Environmental Pressure, including *KLD Rated*, *Positive Environmental Score*, *Positive CSR Score* and *Pension Holdings*. Prior studies show that ESG ratings convey information about firms' sustainability practices and elicit value-relevant responses from investors (see Hartzmark and Sussman, 2019; Krueger, Sautner, and Starks, 2020; Zaccone and Pedrini, 2020). We obtain ESG ratings for U.S. public firms from the KLD database. The variable *KLD Rated* is an indicator equal to one if a firm is covered by the KLD database in a given year, and zero otherwise. We also track the evolution of firms' ESG ratings over time. KLD evaluates each firm across six categories: Community, Diversity, Employee Relations, Environment, Human Rights, and Product. For each category, it reports the number of strengths and concerns. Following Cronqvist and Yu (2017), we compute an aggregate CSR Score by netting the total number of strengths and concerns across all categories—each strength adds one point, while each concern subtracts one point. The variable *Positive CSR Score* is a dummy equal to one if the CSR Score is positive, and zero otherwise. We also focus on the Environment category and create the Environmental Score, defined as the net number of environmental strengths minus concerns. The variable *Positive E Score* equals one if the Environmental Score is positive, and zero otherwise. *Pension Holdings* is defined as an indicator equal to one if the percentage of a company's shares owned by pension funds is above average, and zero otherwise.

We empirically examine how regulatory stringency shapes the market-wide and within-firm effect of pollution intensity on capital allocation and abatement allocation. Table 6 reports the results for both market-wide and within-firm capital allocation. For market-wide capital allocation, Models (1) to (5) show that industries with higher pollution intensity exhibit higher CAPEX/Assets

when firms are KLD-rated, have positive environmental or CSR scores, or when pension ownership is high. The market-wide interaction coefficients are positive or insignificant, suggesting that greater public visibility and institutional monitoring do not induce market-wide capital withdrawal from pollution-intensive activities. Rather, external capital markets appear to continue financing investment in pollution-intensive industries, potentially reflecting capital-intensive compliance upgrades, technology replacement, or regulatory adaptation rather than divestment.

For within-firm capital allocation, the estimates in Models (6) to (10) display the opposite pattern across all pressure measures. The interaction between pollution intensity and environmental pressure is negative and highly significant in the segment-level regressions. Under high pension ownership, the coefficient on the interaction is significantly negative, indicating that headquarters allocate relatively less capital to pollution-intensive segments when long-horizon institutional investors are more prominent. Similar negative interactions are observed for KLD coverage, positive environmental scores, and positive CSR scores. These results imply that greater scrutiny strengthens the sensitivity of internal capital budgeting to pollution risk, leading firms to systematically reallocate investment away from dirtier segments toward cleaner segments within the same organization.

Taken together, Table 6 reveals a consistent divergence between external and internal responses to environmental pressure. Although heightened scrutiny from ESG visibility and pension investors does not reduce market-wide funding to pollution-intensive industries and may even coincide with greater industry-level investment, firms respond by reallocating capital internally away from their more pollution-intensive segments. This evidence suggests that environmental discipline operates primarily through internal capital reallocation rather than through external market-wide divestment, even in the presence of strong institutional ownership and public ESG monitoring.

5.3 Cost of capital

A central implication of recent environmental finance research is that environmental exposure raises firms' cost of capital (e.g., Bolton and Kacperczyk, 2021; Chava, 2014; Hsu, Li, and Tsou, 2023; Gormsen, Huber, and Oh, 2024). If pollution exposure increases the required return demanded by investors and lenders, the firm's hurdle rate rises, potentially reducing investment in pollution-intensive activities. Examining the cost-of-capital channel allows us to connect asset-pricing evidence on environmental risk premium to firms' real investment behavior. We employ two proxies for the cost of capital. The first is the implied cost of capital, constructed following Duan, Li, and Zhang (2024) based on the approach of Easton (2004)[6]. The second is firm perceived cost of capital, we use the data from Gormsen and Huber (2024) that collected based on managerial disclosures from earnings calls, investor conferences, and similar corporate communications over the 2002–2020 period.

Table 7 Panel A reports how firm's implied cost of capital and perceived cost of capital shapes the relationship between pollution intensity and capital allocation. At the industry level, the interaction between pollution intensity and *High CC* is economically small and statistically insignificant across specifications. This indicates that higher financing costs do not differentially reduce investment in more pollution-intensive industries. The lack of significant interaction suggests that capital markets do not selectively tighten funding for dirtier industries when the cost of capital is high.

A similar pattern emerges within firms. The interaction between pollution intensity and High CC remains statistically insignificant in the segment-level regressions, implying that higher financing costs do not amplify the sensitivity of internal capital allocation to pollution intensity. At the same time, the coefficient on High CC is negative and highly significant in both market-wide and within-firm specifications, indicating that higher implied financing costs are associated with a general contraction in investment rather than a targeted reallocation away from pollution-intensive activities.

[6] We use the implied cost of equity rather than realized stock returns to proxy for expected returns because Pastor, Stambaugh, and Taylor (2022) show that realized returns are not a good proxy for expected returns when the demand for green assets unexpectedly increases over a short sample period.

Overall, Table 7 provides little support for a cost-of-capital-driven channel of environmental capital reallocation. Although higher financing costs reduce aggregate investment, they do not differentially penalize pollution-intensive industries or segments. This evidence suggests that the pricing of environmental risk in capital markets does not translate into selective reductions in real investment in dirty activities. Instead, environmental capital reallocation appears to operate primarily through internal capital budgeting and organizational decisions, rather than through external financing constraints induced by a higher cost of capital.

5.4 Financial constraints

A growing literature shows that financial constraints largely shape firms' environmental behavior and internal investment decisions. For example, Giroud and Mueller (2015) demonstrate that internal capital markets become active to reallocate labor and capital when firms are financially constrained. Xu and Kim (2022) show that financially constrained firms emit more toxic pollution because they trade off abatement expenditures against legal liabilities. Bartram, Hou, and Kim (2022) add a spatial reallocation dimension. Studying California's cap-and-trade policy, they show that financially constrained firms respond not by uniformly reducing emissions, but by reallocating production and emissions across plants. Motivated by this literature showing that financial constraints activate internal capital reallocation and shape firms' environmental trade-offs, we therefore examine whether financial constraints amplify the market-wide and within-firm effect of pollution intensity on capital allocation. Our primary measures of financing constraints are the Kaplan and Zingales (1997) KZ index and the Whited and Wu (2006) WW index.

Table 7 Panel B reports results. The results show that the negative within-firm relation between pollution intensity and segment-level investment is substantially stronger among financially constrained firms, whereas the corresponding market-wide industry-level allocation effects are weak. In the market-wide allocation, the interaction between pollution intensity and high financing constraints is generally positive but statistically insignificant under both KZ and

WW measures. This indicates that financing constraints do not materially alter how capital flows across industries in the aggregate.

In contrast, financing constraints play a central role in shaping within-firm capital allocation. In the within-firm across-industry regressions, the interaction between pollution intensity and high financing constraints is consistently negative and highly significant. These estimates imply that financially constrained firms reduce capital expenditures in pollution-intensive segments much more aggressively than unconstrained firms. Economically, the magnitudes are large. For example, using the WW specification, a one–standard-deviation increase in pollution intensity is associated with an additional 0.73 percentage point decline in segment investment for financially constrained firms. Relative to the sample average investment rate of 4.78%, this corresponds to roughly a 15% reduction in investment. This pattern suggests that when external financing is limited, firms reallocate scarce internal capital away from pollution-intensive segments.

Therefore, Table 7 Panel B supports an efficiency-wide interpretation: internal capital markets actively adjust investment in response to environmental exposure, and this adjustment becomes sharper when firms face tighter financing constraints. This mechanism is consistent with evidence in Giroud and Mueller (2015), who show that internal capital markets become more active under financial constraints, reallocating resources toward higher-return projects.

Taken together, the results of Table 7 suggest that price-wide financing conditions (cost of capital) and quantity-wide financing frictions (financial constraints) operate through distinct mechanisms. Environmental capital reallocation does not arise because pollution-intensive activities become more costly to finance at the margin. Instead, it reflects internal capital budgeting responses when firms face limited funding capacity. Environmental discipline is thus primarily an internal allocation phenomenon activated under financial constraints, rather than a direct outcome of capital market pricing.

5.5 Which segments are primarily affected?

To understand which segments inside the firm are most affected by pollution-driven capital reallocation, we exploit two empirical tests. One is whether headquarters treat core and peripheral segments differently, and another one is whether internal capital reallocation depends on segments' financial credibility and environmental compliance capacity.

We first examine whether headquarters treat core and peripheral segments differently. The specification is:

$$Investment_{i,j,t} = \beta_0 + \beta_1 \times Pollution_{i,j,t-1} \times Main_{i,j,t-1} + \beta_2 \times Pollution_{i,j,t-1} \times Peripheral_{i,j,t-1} + A \times X_{i,t-1} + \varepsilon_{i,t} \quad (6)$$

Where $Investment_{i,j,t}$ denotes the ratio of capital expenditure to assets for firm i's allocation to industry j in year t. $Pollution_{i,j,t-1}$is the pollution intensity of firm i's allocation to industry j in year $t-1$. $Main_{i,j,t-1}$and $Peripheral_{i,j,t-1}$are defined based on three criteria: SIC3, employment weight, and sales weight. In Models (1) and (2), *Main* is a dummy equal to 1 if the segment's SIC3 matches the firm's SIC3, otherwise 0. *Peripheral* is defined vice versa. In Models (3) and (4), *Main* equals 1 if the segment's employment weight within the firm is above the median, otherwise 0. *Peripheral* is defined vice versa. In Models (5) and (6), *Main* equals 1 if the segment's sales weight within the firm is above the median, otherwise 0. *Peripheral* is defined vice versa.

In Table 7 Panel A, model (1) to (6) show that the negative effect of pollution intensity on investment is concentrated in peripheral and smaller segments, while core segments are largely unaffected. This pattern suggests that headquarters do not mechanically scale down all polluting activity Instead, they protect core business lines while withdrawing capital from more pollution-intensive segments that are less central to the firm's operations. This pattern is consistent with an efficiency-wide internal capital market: headquarters reallocate capital away from environmentally risky activities primarily when those activities are peripheral and thus easier to scale down without disrupting the firm's main operations.

We next examine whether internal capital reallocation depends on segments' financial credibility and environmental compliance capacity. The specification is:

$$Investment_{i,j,t} = \beta_0 + \beta_1 \times Pollution_{i,j,t-1} \times High_{i,j,t-1} + \beta_2 \times Pollution_{i,j,t-1} \times Low_{i,j,t-1} + A \times X_{i,t-1} + \varepsilon_{i,t} \quad (7)$$

Where $Investment_{i,j,t}$ denotes the ratio of capital expenditure to assets for firm i's allocation to industry j in year t. $Pollution_{i,j,t-1}$is the pollution intensity of firm i's allocation to industry j in year $t-1$. $High_{i,j,t-1}$ is defined as high credit performance or high abatement activity, $Low_{i,j,t-1}$ is defined vice versa. We use Paydex score to construct measures for credit performance. The within-firm across-industry Paydex score is a sales-weighted aggregation of plant-level scores to within-firm 3-digit industry. For the Paydex score, ranging from 0 to 100, represents a business credit score based on trade credit performance reported to Dun & Bradstreet by numerous vendors and suppliers. The score is value-weighted by the size of obligations, with a score of 80 indicating that payments are, on average, made according to agreed loan terms. Our analysis uses the minimum Paydex score reported within each year. *High Credit,* that equals 1 if the minimum Paydex score is above median value, otherwise 0. *Low Credit* is defined vice versa.

In Table 8 Panel B, Model (1) and (2) show the impact of credit performance on internal capital reallocation. The interaction between pollution intensity and *Low Credit* is strongly negative and highly significant, while the coefficients for *High Credit* segments are statistically insignificant. This suggests that when segments have weaker trade-credit performance, headquarters are more willing to reduce capital allocated to pollution-intensive activities. Pollution exposure and financial fragility appear to reinforce each other in capital budgeting decisions. Headquarters thus discipline environmentally risky segments more aggressively when those segments are also financially weaker. Model (3) to (6) examine compliance capacity using abatement activities, which measure source-reduction efforts that limit hazardous substances entering the waste stream. Following Akey and Appel (2021), we distinguish two categories of abatement activities: operating-related abatement and process-related abatement. The negative pollution effect is again concentrated among low-compliance segments. Segments without strong process or operating abatement show a significant negative pollution–investment relation. In contrast, segments with high abatement activity show much weaker or insignificant effects. This pattern indicates that headquarters do not simply penalize pollution mechanically. Instead, they

condition capital allocation on segments' ability to manage environmental risk. Pollution is more strongly associated with capital withdrawal when segments lack mitigation capacity.

Taken together, Table 8 suggests that headquarters incorporate both regulatory risk and segment resilience into capital allocation decisions. Rather than a blanket contraction, internal capital reallocation reflects forward-looking risk management: capital is withdrawn where environmental exposure is high and the segment is less central, less financially robust, or less capable of compliance.

5.6 Which type of pollution drives internal capital reallocation?

To identify which categories of pollution drive within-firm capital reallocation, we decompose total releases into toxic releases, non-toxic releases, onsite toxic releases, and offsite toxic releases, and construct the corresponding pollution-intensity measures. To measure toxic releases, we match facility-level TRI data with the EPA's Integrated Risk Information System (IRIS) using Chemical Abstract Services (CAS) numbers. Toxic Release is defined as the total quantity of releases of all IRIS-identified harmful chemicals at the plant level.

Table 9 uses this decomposition to uncover the channels through which environmental risk affects internal capital allocation. The results show that the negative within-firm investment response is driven entirely by toxic releases, with no economically meaningful effect from non-toxic emissions. Furthermore, within toxic releases, the effect is concentrated on onsite toxic releases, while offsite toxic releases have no significant impact on capital allocation. This pattern indicates that headquarters respond primarily to pollution that is embedded in on-site operations and is harder to mitigate without production adjustments, rather than to emissions that can be outsourced for off-site treatment. Overall, the evidence supports a mechanism in which internal capital markets incorporate forward-looking regulatory and compliance risk when allocating capital across segments.

5.7 Alternative samples

After examining the main mechanisms, we conduct additional robustness tests using alternative samples to address two key concerns related to sample construction and the role of

selling plants. Because our baseline analysis separates market-wide capital allocation from within-firm reallocation, the results could in principle be sensitive to firm composition and to discrete restructuring events such as plant divestitures. In particular, the baseline market-wide specification relies on single-segment firms, and the observed within-firm reallocation could be mechanically driven by firms that sell polluting plants (Duchin et al., 2025). To address these concerns, we (i) expand the market-wide sample to include industries of all firms and (ii) exclude firms that sell polluting plants, thereby isolating continuous capital expenditure decisions from discrete events of selling plants.

Table 10 reports the results. Models (1) and (2) reconstruct market-wide capital allocation using industries of all firms rather than only single-segment firms. The coefficients on pollution intensity remain statistically insignificant, indicating that the absence of market-wide event of selling plants is not driven by the restriction to single-segment firms and is robust to broader industry aggregation. This suggests that external capital markets do not systematically withdraw funding from more pollution-intensive industries even when the full universe of firms is considered.

Models (3) and (4) exclude firms that sell polluting plants. At the market-wide level, the coefficient on pollution intensity becomes positive and statistically significant, implying that capital allocation across industries does not decline—and may even increase—for more pollution-intensive industries once firms of selling plants are removed from the sample. This pattern reinforces the view that the external market does not discipline pollution exposure through reduced investment, and that observed capital flows are not driven by a subset of restructuring firms.

In contrast, Models (5) and (6) show that the within-firm results remain negative and highly significant after excluding selling firms. Firms continue to allocate significantly less capital to more pollution-intensive segments even when events of selling plants are removed, indicating that internal reallocation is not merely a byproduct of plant sales or closures. Instead, headquarters appear to adjust internal capital budgeting across segments in response to pollution intensity, independent of discrete events of selling plants.

Overall, the robustness tests confirm that the central divergence between market-wide and within-firm capital allocation is not driven by firm composition or the behavior of selling plants. While external capital markets do not penalize pollution-intensive industries—even in broader samples or after excluding selling firms—internal capital markets consistently reallocate investment away from more polluting segments within multi-segment firms, highlighting the primacy of internal reallocation as the key channel of environmental discipline.

5.8 Robustness checks

Table 11 presents a comprehensive set of robustness checks using alternative measures of investment, alternative definitions of pollution intensity, and different sample restrictions. Overall, the results strongly reinforce the central pattern documented in the baseline analyses: a persistent divergence between market-wide and within-firm capital allocation in response to pollution intensity.

At the market-wide level (Panels A and C), pollution intensity remains positively and statistically significant across a wide range of specifications. Whether investment is measured as the abatement-adjusted capital ratio, Capex scaled by beginning-of-year assets, log(Capex/assets), or Capex/sales, the coefficients on pollution intensity are consistently positive. This pattern holds when excluding small industries and when restricting the sample to the post-1994 period with more reliable EPA data. Importantly, the positive coefficients also persist when using the abatement-adjusted capital ratio, indicating that the higher investment in pollution-intensive industries is not merely driven by mechanically higher compliance or abatement expenditures. Instead, even after netting out the portion of capital spending explained by environmental abatement, pollution-intensive industries continue to receive comparable or greater external funding.

In contrast, the within-firm results (Panels B and D) remain negative and highly significant across all alternative specifications. Regardless of whether investment is measured using abatement-adjusted capital, Capex over beginning assets, log investment intensity, or Capex over sales, pollution intensity is consistently associated with lower segment-level investment within

multi-segment firms. The magnitude of the negative coefficients is economically meaningful and, in several cases, becomes even larger in the post-1994 subsample, suggesting that internal reallocation away from pollution-intensive segments is at least as strong in periods of improved environmental disclosure and regulatory scrutiny. This pattern is robust when excluding industries with limited firm coverage and when redefining pollution intensity using both releases per employment and releases per sales.

Taken together, these robustness checks confirm that the documented divergence is not driven by measurement choices, sample composition, or the mechanical inclusion of abatement-related investment. Even after adjusting for environmental compliance spending and employing multiple investment proxies, external capital markets do not systematically withdraw funding from pollution-intensive industries, while internal capital markets consistently reallocate investment away from more polluting segments. These results further strengthen the interpretation that environmental discipline operates primarily through internal capital budgeting rather than through market-wide capital rationing.

6. Conclusion

This paper revisits a core premise of environmental and sustainable finance: that capital markets discipline pollution by reallocating investment away from environmentally harmful activities. Using plant-level pollution data linked to firm segments, we provide a direct comparison between market-wide capital allocation across industries and internal capital allocation within multi-segment firms.

Our findings uncover a "green reallocation paradox": while external financial markets do not systematically divest from pollution-intensive industries, and in some cases continue to channel funding toward them. Internal capital markets within multi-segment firms actively reallocate investment away from more polluting segments. We show that market-wide capital expenditures and net funding are positively related to pollution intensity, whereas segment-level investment

within diversified firms declines significantly with pollution exposure. A difference-in-differences analysis exploiting environmental incidents as quasi-exogenous shocks confirms that this divergence is causal: environmental incidents activate within-firm capital reallocation away from pollution-intensive segments but leave market-wide capital flows essentially unchanged, with dynamic event study estimates showing that the reallocation effect emerges sharply at the incident year and intensifies persistently over time. This divergence is not driven by compliance-related abatement spending, events of selling plants, or sample construction. Investigating the mechanisms underlying the divergence, we find that it becomes even stronger under regulatory pressure and public scrutiny from ESG visibility and institutional monitoring, and is primarily activated when firms face binding financial constraints, but is not driven by higher costs of capital. Additional tests reveal that reallocation is concentrated on peripheral and highly toxic, on-site polluting operations, suggesting a targeted and forward-looking managerial response to environmental risk. Overall, the evidence indicates that environmental discipline operates primarily through internal corporate budgeting and restructuring rather than through market-wide capital rationing, highlighting the internal capital market as a central mechanism through which firms adapt to environmental regulation and climate-related risks.

Our findings reshape the understanding of how environmental discipline operates in the real economy. To our knowledge, we are the first to directly compare environmental capital allocation across external markets and within firms, documenting a green reallocation paradox: despite regulatory risk, environmental scrutiny, higher cost of capital, and reputational concerns, pollution intensity does not lead to market-wide capital withdrawal or greater abatement. Instead, consistent with an equilibrium view of green finance, external mechanisms primarily induce re-ownership, relocation, or continued financing of pollution-intensive activities rather than a contraction in aggregate real investment. In contrast, we show that the primary margin of environmental discipline lies inside the firm. Extending the internal capital market literature, we demonstrate that headquarters reallocate capital not only in response to productivity shocks but also to environmental risk shocks, systematically shifting investment away from pollution-intensive

segments even when external markets continue to supply capital to dirty industries. This evidence implies that environmental risk is largely accommodated in external equilibrium but actively managed through internal budgeting and resource allocation. Environmental risk thus represents a new and economically important driver of internal capital allocation, positioning the firm's internal capital market—rather than asset pricing or investor pressure—as the central locus through which environmental risk translates into real changes in production.

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Appendix A. Variable Definitions and Sources

Variables in Panels A through D are at the firm-segment-year level.

Variable	Definition	Source
A. Capital allocation		
Capex/Assets	Firm segment-level capital expenditure divided by total assets and multiply by 100.	Compustat
Capex/Beginning of year Assets	Firm segment-level capital expenditure divided by the beginning of year assets (Assets- Capex + depreciation) and multiply by 100.	Compustat
Log (Capex/Assets)	The logarithm value of Capex/Assets.	Compustat
Capex/Sales	Firm segment-level capital expenditure divided by sales and multiply by 100.	Compustat
Net total funding rate	The total funding rate of an industry (multiply by 100) is the sum of all equity and debt funds raised by the industry's firms during the year, divided by the sum of the total assets of the firms in the industry at the start of the year. Equity funding during a year is computed as the sale of common stock and preferred stock minus the purchase of common and preferred stock. Debt funding is the issuance of long-term debt minus the reduction in long-term debt plus the change in short-term debt. (Lee, Shin and Stulz. 2021)	Compustat
Abatement/Assets	The ratio of Abatement/Assets is defined as the number of segment abatement activities to the segment assets, and times 10000.	EPA P2 and Compustat
B. Pollution related variables		
Total release/employees	This is defined as the total release (pound) divided by employees. Both total release and employees are aggregated from plants level to within-firm across-industry level.	EPA TRI and NETS
Total release/sales	This is defined as the total release(pound) divided by sales. Both total release and sales are aggregated from plants level to within-firm across-industry level.	EPA TRI and NETS
Toxic release/employees	The total toxic release is divided by employees.	EPA TRI RSEI and NETS
Toxic release/sales	The total toxic release is divided by sales.	EPA TRI RSEI and NETS
Non-toxic release/employees	The total non-toxic release is divided by employees. Non-toxic release is the difference between total release and toxic release.	EPA TRI, EPA TRI RSEI and NETS
Non-toxic release/sales	The total non-toxic release is divided by sales. Non-toxic release is the difference between total release and toxic release.	EPA TRI, EPA TRI RSEI and NETS
Toxic Onsite release/employees	The total toxic onsite release is divided by employees.	EPA TRI RSEI and NETS
Toxic Onsite release/sales	The total toxic onsite release is divided by sales.	EPA TRI RSEI and NETS
Toxic Offsite release/employees	The total toxic offsite release is divided by employees.	EPA TRI RSEI and NETS
Toxic Offsite release/sales	The total toxic offsite release is divided by sales.	EPA TRI RSEI and NETS
C. Firm and plants characteristics		

NA Switch	NA Switch is an indicator variable equal to one if a segment's plants are located in counties that transition from attainment to nonattainment status under the Clean Air Act in year t, and zero otherwise.	EPA Greenbook
Implied Cost of Capital	The implied cost of capital is constructed following Duan, Li, and Zhang (2024) based on the approach of Easton (2004). The formula is: $$r_{PEG} = \sqrt{\frac{FEPS_{t+2} - FEPS_{t+1}}{P_t}}$$ Where $FEPS_{t+1}$= 1-year ahead EPS forecast (IBES), $FEPS_{t+2}$= 2-year ahead EPS forecast (IBES) P_t= stock price (lagged price).	IBES and CRSP
Firm Perceived Cost of Capital	This is defined as the firms' implied cost of capital that is collected from the information provided by managers during corporate earnings calls, investor conferences, and similar events from 2002 to 2020 (Gormsen and Huber, 2024).	https://costofcapital.org/
FC_KZ	FC_KZ is a dummy variable that equals 1 if its firm's KZ Index is higher than annual median value of all firms' KZ Index. According to Kaplan and Zingales (1997), KZ Index=-1.002*Cash Flow/Capital +0.283*Tobin's Q+3.139*Debt/Capital-39.368* Cash/Assets -1.315*Dividend/Capital.	Compustat
FC_WW	FC_WW is a dummy variable that equals 1 if its firm's WW Index is higher than annual median value of all firms' WW Index. According to Whited and Wu (2006), WW Index=-0.091*Cash Flow/Assets-0.062*Cash Dividend Dummy+0.021*Long-term debt/assets -0.044* Log (Assets)+0.102*Industry Sales Growth -0.035* Sales Growth.	Compustat
KLD Rated	We define the variable ESG Rated as an indicator equal to one if a firm is covered by the MSCI KLD database each year, and zero otherwise.	MSCI KLD
Positive E Score	The Positive E Score is a dummy variable that equals one if the E Score is positive, otherwise zero. E Score is defined as the difference between the number of environmental strengths (score +1) and environmental concerns (score -1) reported in MSCI KLD data.	MSCI KLD
Positive CSR Score	The Positive CSR Score is a dummy variable that equals one if the CSR Score is positive, otherwise zero. CSR Score is defined as the difference between the number of corporate social responsibility strengths (score +1) and concerns (score -1) reported in MSCI KLD data.	MSCI KLD
Pension Holdings	Pension Holdings is defined as an indicator equal to one if the percentage of a company's shares owned by pension funds is above average, and zero otherwise.	LSEG 13F

Paris Agreement	The Paris Agreement is dummy variables that equals one if the segment belongs to a firm experience the Paris Agreement in 2015, otherwise zero.	/
High (Low) Credit	High Credit equals 1 if the minimum Paydex score is above median value, otherwise 0. Low Credit is defined vice versa. The firm-segment Paydex score is a sales-weighted aggregation of plant-level scores. This score ranges from 0 to 100, is a business credit score based on trade credit performance provided to Dun & Bradstreet by many vendors and suppliers. The score is value-weighted according to size of obligations, and a score of 80 indicates that, on average, payments are made according to the loan terms. Our analysis focuses on the minimum score reported over the course of a year.	NETS
Tobin's Q	(AT-(CEQ+TXDITC) + market value of equity)/AT, where AT is total assets, CEQ is common and ordinary equity, TXDITC is deferred taxes and investment tax credit, and market value of equity is computed as per share price*number of shares outstanding.	Compustat
Cash Flow	(OIBDP-XINT-TXT-DV+INV_INT*0.7)/AT, where AT is total assets lagged by one year, OIBDP is operating income before depreciation, XINT is total interest expense, TXT is total income taxes, DV is cash dividends, and INV_INT is investment in intangibles based on the method of Peters and Taylor (2017).	Compustat
Sales Growth	The dollar changes in annual firm revenue normalized by last year end's market capitalization.	Compustat

Appendix B. A Model of Internal Green Reallocation

We compare a single-sector polluting firm (external-market benchmark) with a two-sector firm operating a productive core and a more polluting peripheral segment (internal capital market). Proofs are in the Online Appendix.

1. Setup

Consider a two-period model ($t = 1,2$). Firms must raise external capital to fund investment, incurring a financing cost r_t per unit invested. Before period 1, nature draws the probability q that environmental pressure will intensify in period 2. Firms observe q and choose period-1 investment. In period 2, the environmental state θ is realized, the firm invests again, and payoffs accrue.

Investment is subject to a quadratic adjustment cost κI_t^2, $\kappa > 0$ (Gould, 1968).[7] With probability q, the high-pressure state $\theta = H$ is realized in period 2; with probability $1 - q$, the low state $\theta = L$ continues. The high state affects firms through two channels:

- **Financing cost** $r_2(\theta)$: the cost of raising external capital for new investment, common across sectors, with $r_2(H) > r_2(L)$. Environmental pressure raises the cost of financing polluting assets.
- **Compliance cost** $\tau^s > 0$: a sector-specific operating cost on all installed capital, active only under pressure ($\tau^s(\theta) = \tau^s \cdot \mathbf{1}_{\{\theta=H\}}$), increasing in the toxicity and on-site intensity of pollution.

Each sector s has production $f^s(K) = A^s K - \frac{b}{2}K^2$ ($A^s > 0$, $b > 0$), yielding a linear-quadratic model with closed-form solutions.[8]

[7] The common alternative $\frac{\kappa}{2} I_t^2 / K_{t-1}$ (Hayashi, 1982) is ill-suited here because the firm builds capital from scratch ($K_0 = 0$). The unscaled specification follows Gould (1968).

[8] Cobb-Douglas production yields nonlinear FOCs that preclude closed-form solutions. The quadratic specification approximates any smooth concave f to second order; qualitative results extend to general concave f via the implicit function theorem.

2. Single-Sector Firm

The firm chooses I_1 at $t = 1$ and $I_2(\theta)$ at $t = 2$, with $K = I_1 + I_2$:

$$V(\theta) = (AK - b/2\,K^2) - r_1 I_1 - r_2(\theta) I_2 - \tau(\theta) K - \kappa I_1^2 - \kappa I_2^2 \qquad \text{(A.1)}$$

We first solve the firm's investment problem in closed form.

Lemma 1 (Single-Sector Optimal Investment). *The optimal investments are:*

$$I_2^*(\theta) = \frac{A - b\,I_1 - r_2(\theta) - \tau(\theta)}{2\kappa + b} \qquad \text{(A.2)}$$

$$I_1^* = \frac{2\kappa(A - \bar{\tau}) + b\,\bar{r}_2 - (2\kappa + b)\,r_1}{4\kappa(\kappa + b)} \qquad \text{(A.3)}$$

where $\bar{r}_2 \equiv \mathbb{E}[r_2(\theta)]$ *and* $\bar{\tau} \equiv q\tau$.

We now ask whether anticipation of environmental pressure increases or decreases current investment.

Proposition 1 (Green Paradox in External Markets).

(a) Polluting firm.

$$\frac{\partial I_1^*}{\partial q} = \frac{b\,\Delta r_2 - 2\kappa\,\tau}{4\kappa(\kappa + b)} \qquad \text{(A.4)}$$

where $\Delta r_2 \equiv r_2(H) - r_2(L) > 0$. *The green paradox* ($\partial I_1^* / \partial q > 0$) *arises if and only if*

$$\Delta r_2 > \frac{2\kappa}{b}\,\tau \qquad \text{(A.5)}$$

Under a general concave f, *the condition becomes* $\Delta r_2 > 2\kappa[I_2^*(L) - I_2^*(H)]$. *With the LQ specification,* $I_2^*(L) - I_2^*(H) = (\Delta r_2 + \tau)/(2\kappa + b)$, *and substituting recovers the closed-form condition* $\Delta r_2 > 2\kappa\tau/b$.

(b) Clean firm benchmark. *A firm with state-independent financing cost* r_2^g *and* $\tau = 0$ *satisfies* $\partial I_1^{g*} / \partial q = 0$. *The green paradox is specific to polluting firms.*

The green paradox condition $\Delta r_2 > 2\kappa\tau/b$ is empirically plausible. Environmental pressure raises the cost of financing polluting assets broadly—through higher risk premia, tighter lending standards, and divestment pressure—while compliance costs apply only to installed capital. In practice, Δr_2 reflects market-wide repricing that is large and immediate, whereas τ accrues gradually through regulatory enforcement. The condition therefore holds whenever financing-cost increases dominate compliance-cost increases, which is the empirically relevant case for most polluting industries. This explains why external capital markets continue to finance—and even expand lending to—polluting firms under rising environmental pressure, consistent with the patterns documented in Tables 2–5.

3. Two-Sector Firm

A two-sector firm operates sectors C (core) and P (peripheral) with $A^C > A^P$ and $\tau^P > \tau^C > 0$. The firm chooses (I_1^C, I_1^P) at $t = 1$ subject to $I_1^C + I_1^P \leq B$,[9] and $(I_2^C(\theta), I_2^P(\theta))$ at $t = 2$. Headquarters maximizes:

$$V(\theta) = \sum_{s\in\{C,P\}} [f^s(K^s) - \tau^s(\theta)K^s - \kappa(I_1^s)^2 - \kappa(I_2^s)^2] - r_1(I_1^C + I_1^P) - r_2(\theta)(I_2^C + I_2^P) \qquad \text{(A.6)}$$

where $K^s = I_1^s + I_2^s$.

Solving the headquarters' problem yields closed-form allocations under the budget constraint.

Lemma 2 (Two-Sector Optimal Investment). *Period-2 investment, given* (I_1^C, I_1^P) *and realized* θ*:*

$$I_2^{s*}(\theta) = \frac{A^s - b\, I_1^s - r_2(\theta) - \tau^s(\theta)}{2\kappa + b} \qquad \text{(A.7)}$$

Period-1 investment, when the budget constraint binds ($I_1^C + I_1^P = B$)*:*

[9] A period-2 constraint $I_2^C + I_2^P \leq B$ is slack in the empirically relevant case and, if binding, only strengthens reallocation toward the core.

$$I_1^{C*} = \frac{B}{2} + \frac{(A^C - A^P) + (\bar{\tau}^P - \bar{\tau}^C)}{4(\kappa + b)} \qquad \text{(A.8)}$$

$$I_1^{P*} = \frac{B}{2} - \frac{(A^C - A^P) + (\bar{\tau}^P - \bar{\tau}^C)}{4(\kappa + b)} \qquad \text{(A.9)}$$

where $\bar{\tau}^s \equiv q\tau^s$.

We next characterize how the two-sector firm's allocation responds to anticipated environmental pressure.

Proposition 2 (Internal Green Reallocation).

$$\frac{\partial I_1^{C*}}{\partial q} = \frac{\tau^P - \tau^C}{4(\kappa + b)} \geq 0 \qquad \text{(A.10)}$$

$$\frac{\partial I_1^{P*}}{\partial q} = -\frac{\tau^P - \tau^C}{4(\kappa + b)} \leq 0 \qquad \text{(A.11)}$$

When $\tau^P > \tau^C$, *the two-sector firm unconditionally reduces peripheral investment and reallocates toward the core.*

The condition $\tau^P > \tau^C$ simply requires that the more polluting peripheral sector faces higher compliance costs than the cleaner core—a condition satisfied by construction in any diversified firm whose segments differ in pollution intensity. Crucially, the financing cost Δr_2 does not appear: the budget constraint absorbs the common financing-cost channel that drives the green paradox in external markets, leaving only the differential compliance-cost channel $\tau^P - \tau^C$. The multi-sector firm therefore simultaneously increases core investment and divests from its polluting periphery, regardless of how large Δr_2 is. This is consistent with the within-firm reallocation patterns documented in Table 2 (Models 5–6) and Table 7 (Panel A), where firms reduce investment in their more polluting segments while expanding cleaner ones.

Corollary 1 (Financial Constraints). *Reallocation is stronger when the budget constraint binds ($\mu > 0$), as peripheral investment carries a direct opportunity cost in foregone core investment.*

We now ask whether external and internal capital markets can respond in opposite directions to the same environmental pressure.

Corollary 2 (Green Paradox vs. Internal Reallocation). *For any $\Delta r_2 > 2\kappa\tau/b$, the green paradox arises for the single-sector firm ($\partial I_1^* / \partial q > 0$) while the two-sector firm simultaneously reduces peripheral investment ($\partial I_1^{P*} / \partial q < 0$).*

We examine which sectors bear the brunt of internal reallocation.

Corollary 3 (Compliance Cost and Pollution Type). *$\partial I_1^P / \partial \tau^P < 0$: sectors with higher compliance costs face stronger divestment pressure.*

4. Discussion

Although the model is deliberately stylized—two periods, two sectors, quadratic costs—it captures the essential economic forces at work and generates predictions that map closely onto the main empirical patterns in our data. We highlight three such connections.

First, single-sector polluting firms and external markets display a green paradox (Proposition 1). Anticipation of environmental pressure does not reduce—and may increase—capital allocation to polluting activities, because the stand-alone firm cannot disinvest without shrinking its core business. This explains the positive relationship between pollution intensity and market-wide capital allocation documented in Tables 2–5: external markets continue to finance polluting industries even under regulatory pressure.

Second, multi-sector firms overcome the paradox through targeted strategic pruning of peripheral dirty operations (Proposition 2). Peripheral assets are less productive and less critical to the firm, so the opportunity cost of divesting is lower. Headquarters possesses greater monitoring and control rights over divisional assets than external owners of stand-alone firms (Gertner,

Scharfstein, and Stein, 1994), enabling more responsive internal reallocation. This explains the negative within-firm relationship between pollution intensity and segment investment (Table 2, Models 5–6), concentrated in peripheral rather than core segments (Table 7, Panel A).

Third, the compliance cost τ^s is increasing in the toxicity and on-site intensity of a sector's pollution (Corollary 3). Sectors generating more toxic, on-site releases face higher compliance costs under pressure, making them the primary target of internal reallocation. This explains why divestment responds to toxic on-site releases rather than non-toxic waste or off-site transfers (Table 8).

Together, these results identify internal capital markets—not external financial markets—as the central arena for real-sector environmental capital reallocation, operating through forward-looking, targeted pruning of peripheral dirty assets under headquarters' direct control.

Table 1. Summary Statistics

The variables, defined in Appendix A, are generally constructed for the period 1990–2021. Panel A presents variables at the within-firm across-industry level, while Panel B shows industry-level variables, which are sales-weighted aggregates of the plant-level data.

Panel A. Within-firm across-industry level variables

	n	mean	std	5%	25%	50%	75%	95%
A. Capital expenditure								
Capex/Assets	9718	4.11	3.89	0.42	1.45	3.21	5.55	11.04
Capex/Beginning of Year Assets	9718	4.96	4.63	0.94	2.25	3.80	6.19	12.48
Log (Capex/Assets)	9718	4.60	3.53	0.95	2.25	3.73	5.92	11.10
Capex/Sales	9718	4.66	4.92	0.99	2.12	3.41	5.60	12.00
B. Pollution related variables								
Total release/employees	9718	1629.09	39138.72	0.00	3.03	41.57	252.75	2026.90
Total release/sales	9718	0.02	0.72	0.00	0.00	0.00	0.00	0.01
Toxic release/employees	9718	1258.16	38609.20	0.00	0.00	11.21	111.20	899.99
Toxic release/sales	9718	0.02	0.71	0.00	0.00	0.00	0.00	0.00
Non-toxic release/employees	9718	371.06	3839.01	0.00	0.03	3.83	60.94	988.94
Non-toxic release/sales	9718	0.00	0.02	0.00	0.00	0.00	0.00	0.00
Toxic Onsite release/employees	9718	1245.28	38608.89	0.00	0.00	7.27	96.48	849.89
Toxic Onsite release/sales	9718	0.02	0.71	0.00	0.00	0.00	0.00	0.00
Toxic Offsite release/employees	9718	12.88	154.66	0.00	0.00	0.00	0.21	25.05
Toxic Offsite release/sales	9718	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Abatement/assets	9718	11.25	47.85	0.00	0.00	0.00	3.5	53.48
C. Firm and plants characteristics								
NA Switch	9718	0.01	0.09	0.00	0.00	0.00	0.00	0.00
Pension Holdings	9718	0.57	0.50	0.00	0.00	1.00	1.00	1.00
KLD Rated	9718	0.47	0.50	0.00	0.00	0.00	1.00	1.00
Positive E Score	9718	0.47	0.50	0.00	0.00	0.00	1.00	1.00
Positive CSR Score	9718	0.31	0.46	0.00	0.00	0.00	1.00	1.00
High CC Dummy	9718	0.30	0.46	0.00	0.00	0.00	1.00	1.00
FC KZ	9718	0.51	0.50	0.00	0.00	1.00	1.00	1.00
FC WW	9718	0.31	0.46	0.00	0.00	0.00	1.00	1.00
Log Paydex	9718	3.06	3.81	4.22	4.29	4.36	4.39	77.00
Tobin's Q	9718	1.65	0.77	0.91	1.18	1.46	1.90	3.07
Cash Flow	9718	0.13	0.07	0.04	0.09	0.13	0.17	0.25
Sales Growth	9718	0.09	2.16	-0.19	-0.02	0.05	0.13	0.32

Panel B. Industry-level variables

	n	mean	std	p5	p25	p50	p75	p95
A. Capital expenditure								
Net Total Funding Rate	1881	0.52	10.91	-9.2	-3.76	-1.01	2.15	14.78
Capex/Assets	1881	4.75	3.12	1.13	2.62	4.14	6.06	10.61
Capex/Beginning of Year Assets	1881	4.84	3.42	1.07	2.58	4.12	6.14	11.25
Log(Capex/Assets)	1881	1.62	0.51	0.76	1.29	1.64	1.95	2.45
Capex/Sales	1881	4.14	3.42	1.04	2.08	3.28	5.2	10
B. Pollution related variables								
Total release/employees	1881	2765.45	29174.58	0.00	7.64	47.92	195.95	1814.21
Total release/sales	1881	0.01	0.09	0.00	0.00	0.00	0.00	0.01
Abatement/assets	1881	14.98	46.82	0	0	1.09	9.96	69.02
C. Firm and plants characteristics								
NA Switch	1881	0.16	0.37	0.00	0.00	0.00	0.00	1.00
Pension Holdings	1881	0.51	0.50	0.00	0.00	1.00	1.00	1.00
KLD Rated	1881	0.14	0.35	0.00	0.00	0.00	0.00	1.00
Positive E Score	1881	0.17	0.38	0.00	0.00	0.00	0.00	1.00
Positive CSR Score	1881	0.47	0.50	0.00	0.00	0.00	1.00	1.00
High CC Dummy	1881	0.68	0.47	0.00	0.00	1.00	1.00	1.00
FC KZ	1881	0.50	0.50	0.00	0.00	1.00	1.00	1.00
FC WW	1881	0.48	0.50	0.00	0.00	0.00	1.00	1.00
Tobin's Q	1881	1.66	0.65	0.96	1.26	1.51	1.87	3.02
Cash Flow	1881	0.13	0.06	0.05	0.09	0.13	0.17	0.24
Sales Growth	1881	0.06	0.15	-0.12	0.00	0.05	0.11	0.27

Table 2. Market-wide and within-firm capital allocation

This table presents the market-wide and within-firm effect of pollution intensity on capital allocation. Model (1) to (2) report how the industry-level pollution intensity affects the net funding rate of single-segment firms. Model (3) to (4) report the results for the industry-level capital investment of single-segment firms. The specification is:

$$Investment_{j,t} = a_0 + a_1 \times Pollution_{j,t-1} + A \times X_{j,t-1} + \varepsilon_{j,t},$$

where $Investment_{j,t}$ denotes the ratio of net total funding (equity and debt) to assets and the ratio of capital expenditure to assets for industry j in year t, $Pollution_{j,t-1}$ is the industry pollution intensity of the previous year. Key explanatory variables are standardized to have mean zero and unit standard deviation. The vector $X_{j,t-1}$ is a set of industry-level control variables, including Tobin's Q, Cash Flow, and Sales Growth. The industry-level variables are value-weighted aggregates from 3-digit industries of plants-level.

Models (5) and (6) show the results for the within-firm across-industry investment among multi-segment firms. The specification is:

$$Investment_{i,j,t} = \beta_0 + \beta_1 \times Pollution_{i,j,t-1} + A \times X_{i,t-1} + \varepsilon_{i,t},$$

where $Investment_{i,j,t}$ denotes the ratio of capital expenditure to assets for firm i's allocation to industry j in year t, $Pollution_{i,j,t-1}$is the pollution intensity of firm i's allocation to industry j in year $t-1$. Key explanatory variables are standardized to have mean zero and unit standard deviation. The vector $X_{i,t-1}$ is a set of firm-level control variables, including Tobin's Q, Cash Flow, and Sales Growth. The sample period is *t* = 1990 to 2021. Appendix A provides detailed definitions. *, **, and *** indicate significance levels of 10%, 5%, and 1%, respectively.

	Market-wide capital allocation				Within-firm capital allocation	
	Net Total Funding Rate		Industry Investment: Capex / Assets		Segment Investment: Capex / Assets	
	(1)	(2)	(3)	(4)	(5)	(6)
Total releases /Employment	0.713***		0.221*		-0.035***	
	(6.77)		(1.94)		(-3.87)	
Total releases /Sales		0.517***		0.197*		-0.030***
		(3.10)		(1.69)		(-3.78)
Tobin's Q	0.502	0.489	0.589***	0.585***	0.259**	0.259**
	(1.12)	(1.09)	(5.96)	(5.93)	(2.24)	(2.24)
Cash Flow	8.110*	8.128*	0.614**	0.612**	6.951***	6.951***
	(1.89)	(1.88)	(2.08)	(2.08)	(5.88)	(5.88)
Sales Growth	1.618	1.614	0.765*	0.764*	-0.007*	-0.007*
	(0.85)	(0.84)	(1.71)	(1.71)	(-1.79)	(-1.79)
Fixed effect	industry, year	industry, year	industry, year	industry, year	firm, segment SIC3, year	firm, segment SIC3, year
Cluster	industry, year	industry, year	industry, year	industry, year	firm, year	firm, year
No. of Obs.	1778	1778	1694	1694	9718	9718
Adj. R-Squared	0.079	0.078	0.431	0.430	0.363	0.363

Table 3. Market-wide and within-firm abatement allocation

This table presents the market-wide and within-firm effect of pollution intensity on abatement allocation. Model (1) to (2) report the results for the industry-level abatement allocation of single-segment firms. The specification is:

$$Abatement_{j,t} = a_0 + a_1 \times Pollution_{j,t-1} + A \times X_{j,t-1} + \varepsilon_{j,t},$$

where $Abatement_{j,t}$ denotes the ratio of abatement activity to assets for industry j in year t, $Pollution_{j,t-1}$ is the industry pollution intensity of the previous year. Key explanatory variables are standardized to have mean zero and unit standard deviation. The vector $X_{j,t-1}$ is a set of industry-level control variables, including Tobin's Q, Cash Flow, and Sales Growth. The industry-level variables are value-weighted aggregates from 3-digit industries of plants-level.

Models (3) and (4) show the results for the within-firm across-industry abatement among multi-segment firms. The specification is:

$$Abatement_{i,j,t} = \beta_0 + \beta_1 \times Pollution_{i,j,t-1} + A \times X_{i,t-1} + \varepsilon_{i,t},$$

where $Abatement_{j,t}$ denotes the ratio of abatement activity to assets for firm i's allocation to industry j in year t, $Pollution_{i,j,t-1}$ is the pollution intensity of firm i's allocation to industry j in year $t-1$. Pollution intensity is defined as total releases divided by employment, and total releases divided by sales. Key explanatory variables are standardized to have mean zero and unit standard deviation. The vector $X_{i,t-1}$ is a set of firm-level control variables, including Tobin's Q, Cash Flow, and Sales Growth. The sample period is t = 1990 to 2021. Appendix A provides detailed definitions. *, **, and *** indicate significance levels of 10%, 5%, and 1%, respectively.

	Market-wide abatement allocation		Within-firm abatement allocation	
	All abatement/ Assets		All abatement/ Assets	
	(1)	(2)	(3)	(4)
Total releases /Employment	0.102		-0.196***	
	(0.10)		(-3.13)	
Total releases /Sales		-0.172		-0.182***
		(-0.15)		(-3.36)
Tobin's Q	-3.661	-3.675	-0.513	-0.512
	(-1.29)	(-1.30)	(-0.65)	(-0.65)
Cash Flow	-4.419	-4.356	-15.391*	-15.385*
	(-0.18)	(-0.18)	(-1.77)	(-1.77)
Sales Growth	-2.950	-2.960	0.564	0.564
	(-0.67)	(-0.67)	(0.32)	(0.32)
Fixed effect	industry, year	industry, year	firm, segment SIC3, year	firm, segment SIC3, year
Cluster	industry, year	industry, year	firm, year	firm, year
No. of Obs.	1702	1702	8770	8770
Adj. R-Squared	0.2	0.2	0.461	0.461

Table 4. Capital investments under exogenous environmental shocks

This table examines the market-wide and within-firm capital allocation under exogenous environmental incident shocks. Panel A compares market-wide (SIC3 industry-level) and within-firm (segment-level) DID results. The market-wide DID specifications are as follows:

$$Investment_{j,t} = a_0 + a_1 \times Pollution_{j,t-1} \times Post_{j,t} + a_2 \times Pollution_{j,t-1} + a_3 \times Post_{j,t} + A \times X_{j,t-1} + \varepsilon_{j,t}$$

where Investment denotes industry-level Capex/Assets for industry j in year t. Pollution is Release/Employees (standardized). Post equals one after the industry's first environmental incident. X is a vector of industry-level controls (Tobin's Q, Cash Flow, Sales Growth). Industry and year fixed effects are included.

The within-firm DID specifications are as follows:

$$Investment_{i,j,t} = \beta_0 + \beta_1 \times Pollution_{i,j,t-1} \times Post_{i,j,t} + \beta_2 \times Pollution_{i,j,t-1} + \beta_3 \times Post_{i,j,t} + A \times X_{i,t-1} + \varepsilon_{i,t}$$

where Investment denotes segment-level Capex/Assets (×100) for firm i's segment in industry j in year t. Pollution is the segment's Release/Employees (standardized). Post equals one after the firm's first environmental incident. X is a vector of firm-level controls. Firm, segment industry (SIC3), and year fixed effects are included.

Panel B presents event study estimates that trace the effect of environmental risk incidents on within-firm capital allocation over event time (−3 to +3 years, base = −1). The specification is as follows:

$$Investment_{i,j,t} = b_0 + \sum_{-3}^{+3} b_\tau \times Pollution_{i,j,t-1} * Event(\tau) + b_7 \times Pollution_{i,j,t-1} + b_8 \times Event\ [-3, +3], + A \times X_{i,t-1} + \varepsilon_{i,t},$$

where $Investment_{i,j,t}$ denotes the ratio of capital expenditure to assets for firm i's allocation to industry j in year t, $Pollution_{i,j,t-1}$ is the pollution intensity (Total releases/Employment) of firm i's allocation to industry j in year $t-1$, $Event(\tau)$ is a dummy equal to one if year t falls τ years relative to an environmental incident reported by RepRisk. *Event [-3, +3]* is an indicator for the event window. The vector $X_{i,t-1}$ is a set of firm-level control variables, including Tobin's Q, Cash Flow, and Sales Growth. The t-statistics in parentheses. *, **, *** denote significance at 10%, 5%, 1%.

Panel C shows the figure that plots within-firm event study coefficients (Pollution Intensity × Event Time dummies) based on the Panel B regression. The vertical dashed line marks the incident year. Base period is t = −1. Error bars are 90% confidence intervals. Never-treated firms serve as controls.

Panel A. DID estimations

	Market-wide capital allocation		Within-firm capital allocation	
	Industry Investment: Capex / Assets		Segment Investment: Capex / Assets	
	(1)	(2)	(3)	(4)
Total releases/Employment × Post	-0.097	-0.084	-0.968**	-1.263***
	(-0.96)	(-0.81)	(-2.41)	(-2.82)
Post	0.189	0.249	0.093	0.096
	(0.50)	(0.59)	(0.42)	(0.40)
Total releases/Employment	0.216*	0.192	-0.036***	-0.029**
	(1.93)	(1.66)	(-3.27)	(-2.42)
Tobin's Q	0.415***		0.258	
	(4.77)		(1.41)	
Cash Flow	4.333***		8.661***	
	(3.72)		(6.61)	
Sales Growth	0.176		0.135	

	(0.39)		(0.58)	
Fixed effect	Industry, year	Industry, year	Firm, industry, year	Firm, industry, year
Clustering	Industry, year	Industry, year	Firm	Firm
Observations	1,682	1,682	8,476	8,476
R^2	0.483	0.456	0.444	0.427

Panel B. Dynamic effects in within-firm capital allocation

	Within-firm capital allocation Segment investment: Capex/Assets
Total releases/Employment ×Event (t = −3)	-3.645
	(-0.74)
Total releases/Employment × Event (t = −2)	3.438
	(0.56)
Total releases/Employment × Event (t = 0)	-4.719*
	(-1.65)
Total releases/Employment × Event (t = +1)	-4.883**
	(-2.38)
Total releases/Employment × Event (t = +2)	-5.271**
	(-2.21)
Total releases/Employment × Event (t = +3)	-5.889**
	(-2.34)
Fixed effect	Firm, industry, year
Clustering	Firm
Observations	4,778
R^2	0.517

Panel C. Figure for the dynamic effects in within-firm capital allocation

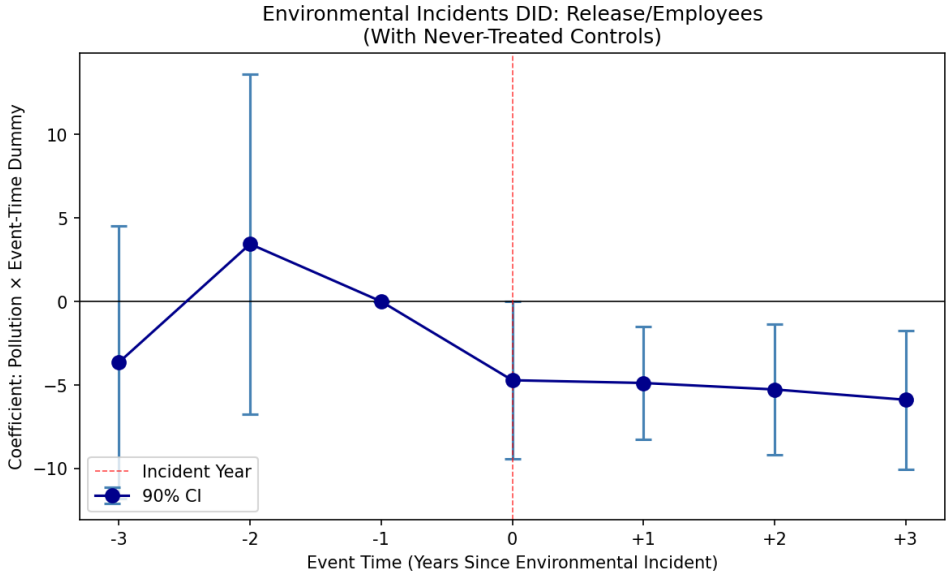


Table 5. The impact of regulatory shock

This table reports how regulatory stringency shapes the market-wide and within-firm effect of pollution intensity on capital allocation and abatement allocation. We use the NA Switch as the regulatory shock. NA Switch is an indicator variable equal to one if a segment's plants are located in counties that transition from attainment to nonattainment status under the Clean Air Act in year t, and zero otherwise. In Panel A, we show how regulatory shock affects capital allocation. In Panel B, we show how the regulatory shock affects abatement allocation. Model (1) and (2) report the results for the industry-level capital investment of single-segment firms. The specification is:

$$Investment_{j,t} = a_0 + a_1 \times Pollution_{j,t-1} \times RegShock_{j,t-1} + a_2 \times Pollution_{j,t-1} + a_3 \times RegShock_{j,t-1} + A \times X_{j,t-1} + \varepsilon_{j,t},$$

where $Investment_{j,t}$ denotes the ratio of net total funding (equity and debt) to assets and the ratio of capital expenditure to assets for industry j in year t, $Pollution_{j,t-1}$ is the industry pollution intensity of the previous year. Key explanatory variables are standardized to have mean zero and unit standard deviation. The vector $X_{j,t-1}$ is a set of industry-level control variables, including Tobin's Q, Cash Flow, and Sales Growth. The industry-level variables are value-weighted aggregates from 3-digit industries of plants-level.

Models (3) and (4) show the results for the within-firm across-industry investment among multi-segment firms. The specification is:

$$Investment_{i,j,t} = \beta_0 + \beta_1 \times Pollution_{i,j,t-1} \times RegShock_{i,j,t-1} + \beta_2 \times Pollution_{i,j,t-1} + \beta_3 \times RegShock_{i,j,t-1} + A \times X_{i,t-1} + \varepsilon_{i,t},$$

where $Investment_{i,j,t}$ denotes the ratio of capital expenditure to assets for firm i's allocation to industry j in year t, $Pollution_{i,j,t-1}$is the pollution intensity of firm i's allocation to industry j in year $t-1$. Key explanatory variables are standardized to have mean zero and unit standard deviation. The vector $X_{i,t-1}$ is a set of firm-level control variables, including Tobin's Q, Cash Flow, and Sales Growth. The sample period is t = 1990 to 2021. Appendix A provides detailed definitions. *, **, and *** indicate significance levels of 10%, 5%, and 1%, respectively.

Panel A. Nonattainment shock on capital allocation

	Market-wide capital allocation		Within-firm capital allocation	
	Industry Investment: Capex / Assets		Segment Investment: Capex / Assets	
	(1)	(2)	(3)	(4)
Total releases /Employment * NA switch	0.068***		-0.853***	
	(4.66)		(-3.70)	
Total releases /Employment	0.203**		-0.035***	
	(2.71)		(-3.66)	
Total releases /Sales * NA switch		0.095***		-0.716***
		(3.37)		(-3.66)
Total releases /Sales		0.181		-0.031***
		(1.68)		(-3.84)
NA switch	-0.737*	-1.152*	-0.545**	-0.534**
	(-1.73)	(-1.99)	(-2.40)	(-2.29)
Tobin's Q	0.414***	0.412***	0.256**	0.256**
	(4.79)	(4.77)	(2.21)	(2.21)
Cash Flow	4.353***	4.359***	6.980***	6.981***
	(3.66)	(3.65)	(5.91)	(5.90)
Sales Growth	0.178	0.168	-0.007*	-0.007*
	(0.39)	(0.37)	(-1.78)	(-1.81)
Fixed effect	industry, year	industry, year	firm, segment SIC3, year	firm, segment SIC3, year

Cluster	industry, year	industry, year	firm, year	firm, year
No. of Obs.	1682.000	1682.000	9718.000	9718.000
Adj. R-Squared	0.440	0.440	0.363	0.363

Panel B. Nonattainment shock on abatement allocation

	Market-wide abatement allocation		Within-firm abatement allocation	
	All abatement/Assets		All abatement/ Segment Assets	
	(1)	(2)	(3)	(4)
Total releases /Employment * NA switch	-1.234***		-0.242	
	(-6.17)		(-0.38)	
Total releases /Employment	0.009		-0.190***	
	(0.01)		(-2.89)	
Total releases /Sales * NA switch		-1.313***		-0.346
		(-8.15)		(-0.49)
Total releases /Sales		-0.286		-0.176***
		(-0.28)		(-3.14)
NA switch	-8.005	-7.866	-1.862	-1.805
	(-1.43)	(-1.41)	(-1.04)	(-1.01)
Tobin's Q	-3.842	-3.870	-0.569	-0.569
	(-1.33)	(-1.33)	(-0.83)	(-0.83)
Cash Flow	-3.966	-3.608	-11.290	-11.284
	(-0.17)	(-0.15)	(-1.54)	(-1.53)
Sales Growth	-3.062	-3.117	0.008	0.008
	(-0.68)	(-0.69)	(0.50)	(0.50)
Fixed effect	industry, year	industry, year	firm, segment SIC3, year	firm, segment SIC3, year
Cluster	industry, year	industry, year	firm, year	firm, year
No. of Obs.	1702.000	1702.000	8916	8916
Adj. R-Squared	0.199	0.200	0.461	0.461

Table 6. Environmental Pressure

This table reports how regulatory stringency shapes the market-wide and within-firm effect of pollution intensity on capital allocation and abatement allocation. Env Pressure is measured by four variables: *KLD Rated, Positive E Score, Positive CSR Score,* and *Pension Holdings*. The KLD Rated is a dummy variable that equals one if the segment belongs to a firm that is covered by MSCI KLD ESG rating, otherwise zero. *E Score* is defined as the difference between the number of environmental strengths (score +1) and environmental concerns (score -1) reported in MSCI KLD data. *Positive CSR Score* is a dummy variable that equals one if the CSR Score is positive, otherwise zero. CSR Score is defined as the difference between the number of corporate social responsibility strengths (score +1) and concerns (score -1) reported in MSCI KLD data. In Panel D, *Pension Holdings* is defined as an indicator equal to one if the percentage of a company's shares owned by pension funds is above average, and zero otherwise. Model (1) and (4) report the results for the industry-level capital investment of single-segment firms. The specification is:

$$Investment_{j,t} = a_0 + a_1 \times Pollution_{j,t-1} \times Env\ Pressure_{j,t-1} + a_2 \times Pollution_{j,t-1} + a_3 \times Env\ Pressure_{j,t-1} + A \times X_{j,t-1} + \varepsilon_{j,t},$$

where $Investment_{j,t}$ denotes the ratio of net total funding (equity and debt) to assets and the ratio of capital expenditure to assets for industry j in year t, $Pollution_{j,t-1}$ is the industry pollution intensity of the previous year. Key explanatory variables are standardized to have mean zero and unit standard deviation. The vector $X_{j,t-1}$ is a set of industry-level control variables, including Tobin's Q, Cash Flow, and Sales Growth. The industry-level variables are value-weighted aggregates from 3-digit industries of plants-level.

Models (5) and (8) show the results for the within-firm across-industry investment among multi-segment firms. The specification is:

$$Investment_{i,j,t} = \beta_0 + \beta_1 \times Pollution_{i,j,t-1} \times Env\ Pressure_{i,j,t-1} + \beta_2 \times Pollution_{i,j,t-1} + \beta_3 \times Env\ Pressure_{i,j,t-1} + A \times X_{i,t-1} + \varepsilon_{i,t},$$

where $Investment_{i,j,t}$ denotes the ratio of capital expenditure to assets for firm i's allocation to industry j in year t. $Pollution_{i,j,t-1}$is the pollution intensity of firm i's allocation to industry j in year $t-1$. Key explanatory variables are standardized to have mean zero and unit standard deviation. The vector $X_{i,t-1}$ is a set of firm-level control variables, including Tobin's Q, Cash Flow, and Sales Growth.

Appendix A provides detailed definitions. All specifications include firm, industry sic3 and year fixed effects. Standard errors are clustered by firm and year. Robust t-statistics are reported in parentheses. *, **, and *** indicate 10%, 5%, and 1% levels of significance, respectively.

	Market-wide capital allocation				Within-firm capital allocation			
	Industry Investment: Capex /Assets				Segment Investment: Capex /Assets			
	KLD Rated	Positive E Score	Positive CSR	Pension Holdings	KLD Rated	Positive E Score	Positive CSR	Pension Holdings
	(1)	(2)	(1)	(2)	(1)	(2)	(1)	(2)
Total releases /Employment*Env Pressure	0.441**	0.127***	0.096**	0.115	-0.032***	-0.032***	-0.032***	-0.104**
	(2.67)	(4.23)	(2.59)	(0.37)	(-3.19)	(-3.19)	(-3.19)	(-2.28)
Total releases /Employment	-0.204	0.198**	0.192**	0.035	-0.026***	-0.026***	-0.026***	-0.037***
	(-1.19)	(2.65)	(2.56)	(0.10)	(-2.99)	(-3.00)	(-3.00)	(-3.10)
Env Pressure	4.341***	-0.097	0.207	0.395**	0.125	0.260	0.260	0.469**
	(3.75)	(-0.39)	(0.96)	(2.30)	(1.38)	(1.39)	(1.39)	(2.68)
Control Variables	YES	YES	YES	YES	YES	YES	YES	YES
Fixed effect	industry, year	industry, year	industry, year	industry, year	firm, segment SIC3, year	firm, segment SIC3, year	firm, segment SIC3, year	firm, segment SIC3, year
Cluster	industry, year	industry, year	industry, year	industry, year	firm, year	firm, year	firm, year	firm, year
No. of Obs.	1682	1682	1682	1694	8475	8475	8475	9718
Adj. R-Squared	0.444	0.441	0.441	0.440	0.401	0.401	0.401	0.363

Table 7. Cost of Capital and Financial Constraints

This table reports how firms' cost of capital and financial constraints shape the market-wide and within-firm effect of pollution intensity on capital allocation. In Panel A, we employ two proxies for the cost of capital. The first is the implied cost of capital, constructed following Easton (2004). The second is firm perceived cost of capital, based on managerial disclosures from earnings calls, investor conferences, and similar corporate communications over the 2002–2020 period (Gormsen and Huber, 2024). In Panel B, we use two proxies for financing constraints. The first one is KZ index of Kaplan and Zingales (1997), and the second one is WW index of Whited and Wu (2006). Model (1) and (4) report the results for the industry-level capital investment of single-segment firms. The specification is:

$$Investment_{j,t} = a_0 + a_1 \times Pollution_{j,t-1} \times High_{j,t-1} + a_2 \times Pollution_{j,t-1} + a_3 \times High_{j,t-1} + A \times X_{j,t-1} + \varepsilon_{j,t},$$

where $Investment_{j,t}$ denotes the ratio of net total funding (equity and debt) to assets and the ratio of capital expenditure to assets for industry j in year t. *High* is an indicator equal to one if an industry's cost of capital (or financial constraints) is above the cross-industry median in a given year, and zero otherwise. Industry-level cost of capital is constructed as the value-weighted aggregate of firm-level measures. $Pollution_{j,t-1}$ is the industry pollution intensity of the previous year. Key explanatory variables are standardized to have mean zero and unit standard deviation. The vector $X_{j,t-1}$ is a set of industry-level control variables, including Tobin's Q, Cash Flow, and Sales Growth. The industry-level variables are value-weighted aggregates from 3-digit industries of plants-level.

Models (5) and (8) show the results for the within-firm across-industry investment among multi-segment firms. The specification is:

$$Investment_{i,j,t} = \beta_0 + \beta_1 \times Pollution_{i,j,t-1} \times High_{i,j,t-1} + \beta_2 \times Pollution_{i,j,t-1} + \beta_3 \times High_{i,j,t-1} + A \times X_{i,t-1} + \varepsilon_{i,t},$$

where $Investment_{i,j,t}$ denotes the ratio of capital expenditure to assets for firm i's allocation to industry j in year t. $Pollution_{i,j,t-1}$ is the pollution intensity of firm i's allocation to industry j in year $t-1$. *High* equals one if the firm's cost of capital (or financial constraints) is higher than the median value in a given year, otherwise zero. The vector $X_{i,t-1}$ is a set of firm-level control variables, including Tobin's Q, Cash Flow, and Sales Growth. The sample period is t = 2002 to 2021. Appendix A provides detailed definitions. All specifications include firm, industry sic3 and year fixed effects. Standard errors are clustered by firm and year. Robust t-statistics are reported in parentheses. *, **, and *** indicate 10%, 5%, and 1% levels of significance, respectively.

Panel A. Cost of Capital

	Market-wide capital allocation				Within-firm capital allocation			
	Industry Investment: Capex /Assets				Segment Investment: Capex /Assets			
	Implied Cost of Capital		Firm Perceived Cost of Capital		Implied Cost of Capital		Firm Perceived Cost of Capital	
	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)
Total releases /Employment * High CC	-0.065		0.046		-0.003		0.331	
	(-1.22)		(0.71)		(-0.52)		(1.29)	
Total releases /Employment	0.222***		0.184***		-0.039***		-1.227**	
	(2.78)		(3.13)		(-2.98)		(-2.44)	
Total releases /Sales * High CC		-0.033		-0.024		-0.002		0.031
		(-0.67)		(-0.20)		(-0.39)		(0.25)
Total releases /Sales		0.169		0.199**		-0.036***		-4.637**
		(1.60)		(2.19)		(-2.76)		(-2.60)
High CC	-0.460***	-0.460***	0.266	0.295	-0.331***	-0.332***	-0.132	-0.099
	(-2.86)	(-2.86)	(1.27)	(1.44)	(-3.28)	(-3.28)	(-0.47)	(-0.35)
Tobin's Q	0.385***	0.383***	0.409***	0.406***	0.234**	0.234**	0.390*	0.421**
	(4.33)	(4.29)	(4.82)	(4.75)	(2.15)	(2.15)	(2.01)	(2.13)
Cash Flow	3.857***	3.865***	4.366***	4.301***	6.447***	6.448***	5.182***	5.110***
	(3.32)	(3.32)	(3.86)	(3.85)	(5.40)	(5.40)	(5.65)	(5.35)
Sales Growth	-0.009	-0.009	0.191	0.195	-0.007**	-0.007*	0.327	0.353
	(-0.02)	(-0.02)	(0.42)	(0.43)	(-2.09)	(-2.03)	(0.90)	(0.96)
Fixed effect	Ind, year	Ind, year	Ind, year	Ind, year	firm, segment SIC3, year	firm, segment SIC3, year	firm, segment SIC3, year	firm, segment SIC3, year
Cluster	Ind, year	Ind, year	Ind, year	Ind, year	firm, year	firm, year	firm, year	firm, year
No. of Obs.	1682.000	1682.000	1234	1234	9718	9718	3933	3933
Adj. R-Squared	0.441	0.440	0.441	0.440	0.364	0.364	0.386	0.386

Panel B. Financial Constraints

	Market-wide capital allocation				Within-firm capital allocation			
	Industry Investment: Capex /Assets				Segment Investment: Capex /Assets			
	KZ Index		WW Index		Implied Cost of Capital		Firm Perceived Cost of Capital	
	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)
Total releases /Employment * High FC	0.261		0.681		-0.051***		-0.729**	
	(1.12)		(0.72)		(-5.72)		(-2.19)	
Total releases /Employment	-0.033		-0.453		-0.025***		-0.031***	
	(-0.12)		(-0.48)		(-3.12)		(-3.33)	
Total releases /Sales * High FC		0.404*		0.579		-0.027***		-0.385*
		(1.65)		(0.91)		(-8.53)		(-2.03)
Total releases /Sales		-0.211		-0.361		-0.023***		-0.028***
		(-0.76)		(-0.56)		(-3.35)		(-3.28)
High KZ	-0.325***	-0.330***	0.311	0.315	-0.238*	-0.241*	0.078	0.071
	(-4.64)	(-4.71)	(1.41)	(1.42)	(-1.90)	(-1.92)	(0.53)	(0.47)
Tobin's Q	0.575***	0.571***	0.676***	0.673***	0.254	0.254	0.263	0.263
	(5.92)	(5.90)	(4.88)	(4.83)	(1.51)	(1.51)	(1.52)	(1.52)
Cash Flow	0.571**	0.569**	0.568**	0.571**	8.529***	8.525***	8.604***	8.608***
	(2.00)	(2.00)	(2.46)	(2.47)	(5.35)	(5.34)	(5.29)	(5.29)
Sales Growth	0.831*	0.833*	0.780*	0.781*	0.182	0.183	0.165	0.171
	(1.83)	(1.84)	(1.78)	(1.78)	(0.65)	(0.66)	(0.60)	(0.62)
Fixed effect	Ind, year	Ind, year	Ind, year	Ind, year	firm, segment SIC3, year	firm, segment SIC3, year	firm, segment SIC3, year	firm, segment SIC3, year
Cluster	Ind, year	Ind, year	Ind, year	Ind, year	firm, year	firm, year	firm, year	firm, year
No. of Obs.	1694.000	1694.000	1682.000	1682.000	8476	8476	8476	8476
Adj. R-Squared	0.437	0.437	0.435	0.435	0.401	0.401	0.401	0.401

Table 8. Which segments are primarily affected?

This table reports which segments are more likely to be affected. In Panel A, *Main* and *Peripheral* are defined based on three criteria: SIC3, employment weight, and sales weight. The specification is:

$$Investment_{i,j,t} = \beta_0 + \beta_1 \times Pollution_{i,j,t-1} \times Main_{i,j,t-1} + \beta_2 \times Pollution_{i,j,t-1} \times Peripheral_{i,j,t-1} + A \times X_{i,t-1} + \varepsilon_{i,t}$$

Where $Investment_{i,j,t}$ denotes the ratio of capital expenditure to assets for firm i's allocation to industry j in year t. $Pollution_{i,j,t-1}$ is the pollution intensity of firm i's allocation to industry j in year $t-1$. $Main_{i,j,t-1}$ and $Peripheral_{i,j,t-1}$ are defined based on three criteria: SIC3, employment weight, and sales weight. In Models (1) and (2), *Main* is a dummy equal to 1 if the segment's SIC3 matches the firm's SIC3, otherwise 0. *Peripheral* is defined vice versa. In Models (3) and (4), *Main* equals 1 if the segment's employment weight within the firm is above the median, otherwise 0. *Peripheral* is defined vice versa. In Models (5) and (6), *Main* equals 1 if the segment's sales weight within the firm is above the median, otherwise 0. *Peripheral* is defined vice versa. Key explanatory variables are standardized to have mean zero and unit standard deviation.

Panel B shows the credit of compliance of segments. The specification is:

$$Investment_{i,j,t} = \beta_0 + \beta_1 \times Pollution_{i,j,t-1} \times High_{i,j,t-1} + \beta_2 \times Pollution_{i,j,t-1} \times Low_{i,j,t-1} + A \times X_{i,t-1} + \varepsilon_{i,t}$$

Where $High_{i,j,t-1}$ is defined as high credit performance or high abatement activity, $Low_{i,j,t-1}$ is defined vice versa. In Models (1) and (2), the credit performance of segment is a sales-weighted aggregation of plant-level Paydex scores. *High Credit* equals 1 if the minimum Paydex score is above median value, otherwise 0. *Low Credit* is defined vice versa. In Model (3) to (6), the compliance of environmental protection is measured by abatement activities. *High Process Abatement* equals 1 if the segment has at least one process abatement activity, otherwise 0. *High Operating Abatement* equals 1 if the segment has at least one operating abatement activity, otherwise 0. Key explanatory variables are standardized to have mean zero and unit standard deviation. Appendix A provides detailed definitions. All specifications include firm, industry sic3 and year fixed effects. Standard errors are clustered by firm and year. Robust t-statistics are reported in parentheses. *, **, and *** indicate 10%, 5%, and 1% levels of significance, respectively.

Panel A. Main and peripheral segments

	Within-firm capital allocation					
	Capex/Assets					
	Same SIC3		Employment weight		Sales weight	
	(1)	(2)	(3)	(4)	(5)	(6)
Total releases /Employment * Main	0.116		-0.212		-0.175	
	(0.56)		(-1.20)		(-0.97)	
Total releases /Employment * Peripheral	-0.034***		-0.028***		-0.028***	
	(-3.43)		(-3.25)		(-3.29)	
Total releases /Sales * Main		0.297		-0.048		-0.025
		(1.69)		(-0.20)		(-0.10)
Total releases /Sales *Peripheral		-0.029***		-0.028***		-0.028***
		(-3.32)		(-3.29)		(-3.30)
Tobin's Q	0.262	0.260	0.260	0.261	0.260	0.261
	(1.52)	(1.51)	(1.51)	(1.52)	(1.51)	(1.52)
Cash Flow	8.645***	8.648***	8.632***	8.637***	8.634***	8.639***
	(5.28)	(5.28)	(5.28)	(5.27)	(5.28)	(5.28)
Sales Growth	0.168	0.161	0.167	0.168	0.166	0.167

	(0.61)	(0.58)	(0.60)	(0.60)	(0.60)	(0.60)
Fixed effect	firm, industry sic3, year	firm, industry sic3, year	firm, industry sic3, year	firm, industry sic3, year	firm, industry sic3, year	firm, industry sic3, year
Cluster	firm, year	firm, year	firm, year	firm, year	firm, year	firm, year
No. of Obs.	8475	8475	8475	8475	8475	8475
Adj. R-Squared	0.400	0.401	0.400	0.401	0.400	0.401

Panel B. Credit and Compliance of segments

	Within-firm capital allocation					
	Capex/Assets					
	Credit Performance		Process Abatement		Operating Abatement	
	(1)	(2)	(3)	(4)	(5)	(6)
Total releases /Employment * High	0.306		0.092		-0.025**	
	(1.53)		(0.12)		(-2.57)	
Total releases /Employment * Low	-0.034***		-0.033***		-0.022***	
	(-3.43)		(-3.50)		(-3.90)	
Total releases /Sales * High		0.285		0.131		0.131
		(1.47)		(0.20)		(0.20)
Total releases /Sales *Low		-0.028***		-0.028***		-0.028***
		(-3.31)		(-3.28)		(-3.28)
Tobin's Q	0.259	0.258	0.261	0.261	0.261	0.261
	(1.51)	(1.51)	(1.51)	(1.51)	(1.51)	(1.51)
Cash Flow	8.656***	8.649***	8.643***	8.644***	8.641***	8.644***
	(5.25)	(5.26)	(5.30)	(5.30)	(5.28)	(5.30)
Sales Growth	0.161	0.163	0.166	0.166	0.166	0.166
	(0.57)	(0.58)	(0.60)	(0.60)	(0.60)	(0.60)
Fixed effect	firm, industry sic3, year	firm, industry sic3, year	firm, industry sic3, year	firm, industry sic3, year	firm, industry sic3, year	firm, industry sic3, year
Cluster	firm, year	firm, year	firm, year	firm, year	firm, year	firm, year
No. of Obs.	8475	8475	8475	8475	8475	8475
Adj. R-Squared	0.400	0.401	0.400	0.400	0.400	0.400

Table 9. The decomposition of pollution intensity

This table presents the within-firm effects of pollution intensity on capital allocation by examining different pollution sources. We decompose the Total Release as four components: toxic, non-toxic, toxic onsite, and toxic offsite releases. Model (1) and (2) report the results of pollution intensity by using *Toxic Release*. Model (3) and (4) report the results of pollution intensity by using *Non-toxic Release*, that is defined as the Total Release minus Toxic Releases. Model (5) and (6) report the results of pollution intensity by using *Toxic Onsite Release*, that is the total toxic onsite release. Model (7) and (8) report the results of pollution intensity by using *Toxic Offsite Release*, that is the total toxic offsite release. Key explanatory variables are standardized to have mean zero and unit standard deviation. Appendix A provides detailed definitions. All specifications include firm, industry sic3 and year fixed effects. Standard errors are clustered by firm and year. Robust t-statistics are reported in parentheses. *, **, and *** indicate 10%, 5%, and 1% levels of significance, respectively.

	Within-firm capital allocation							
	Segment Investment: Capex / Assets							
	Toxic Releases		Non-Toxic Releases		Toxic Onsite Releases		Toxic Offsite Releases	
	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)
Decomposed releases /Employment	-0.032***		-0.078		-0.032***		-0.096	
	(-3.47)		(-0.71)		(-3.47)		(-1.25)	
Decomposed releases /Sales		-0.028***		-0.021		-0.028***		0.047
		(-3.31)		(-0.58)		(-3.32)		(0.44)
Tobin's Q	0.262	0.262	0.263	0.263	0.262	0.262	0.263	0.263
	(1.52)	(1.52)	(1.52)	(1.53)	(1.52)	(1.52)	(1.52)	(1.52)
Cash Flow	8.634***	8.634***	8.608***	8.612***	8.634***	8.634***	8.618***	8.614***
	(5.29)	(5.28)	(5.27)	(5.28)	(5.29)	(5.28)	(5.28)	(5.28)
Sales Growth	0.163	0.163	0.166	0.167	0.163	0.163	0.166	0.168
	(0.59)	(0.59)	(0.60)	(0.61)	(0.59)	(0.59)	(0.60)	(0.61)
	firm,	firm,	firm,	firm,	firm,	firm,	firm,	firm,
	industry	industry	industry	industry	industry	industry	industry	industry
Fixed effect	sic3, year	sic3, year	sic3, year	sic3, year	sic3, year	sic3, year	sic3, year	sic3, year
Cluster	firm, year	firm, year	firm, year	firm, year	firm, year	firm, year	firm, year	firm, year
No. of Obs.	8475.000	8475.000	8475.000	8475.000	8475.000	8475.000	8475.000	8475.000
Adj. R-Squared	0.401	0.401	0.400	0.400	0.401	0.401	0.400	0.400

Table 10. Alternative samples and measures

This table presents robustness checks by using alternative samples and measures. Model (1) and (2) report the results for market-wide capital allocation by using the industries of all firms, instead of the single-segment firms. Model (3) and (4) report the market-wide results by excluding firms that sell plants. Model (5) and (6) report the within-firm results by excluding firms that sell plants. We employ the firm-level events of selling plants dataset from Duchin et al., (2025) and delete observations for a firm in all years strictly after its first selling year. Key explanatory variables are standardized to have mean zero and unit standard deviation. The sample period is t = 1990 to 2021. Appendix A provides detailed definitions. *, **, and *** indicate significance levels of 10%, 5%, and 1%, respectively.

	Market-wide capital allocation		Market-wide capital allocation		Within-firm capital allocation	
	Industry Investment: Capex / Assets		Industry Investment: Capex / Assets		Segment Investment: Capex / Assets	
	Industries of all firms		Drop firms selling plants		Drop firms selling plants	
	(1)	(2)	(3)	(4)	(5)	(6)
Total releases /Employment	-0.019		0.156**		-0.047***	
	(-0.21)		(2.61)		(-3.49)	
Total releases /Sales		-0.023		0.142*		-0.044***
		(-0.24)		(1.89)		(-3.55)
Tobin's Q	0.200	0.200	0.426***	0.424***	0.195	0.195
	(1.32)	(1.31)	(3.90)	(3.89)	(1.52)	(1.52)
Cash Flow	8.693***	8.696***	4.163**	4.151**	7.706***	7.707***
	(4.29)	(4.29)	(2.53)	(2.52)	(5.65)	(5.65)
Sales Growth	0.103	0.102	-0.169	-0.169	-0.008**	-0.008**
	(0.18)	(0.17)	(-0.38)	(-0.38)	(-2.19)	(-2.19)
Fixed effect	industry, year	industry, year	industry, year	industry, year	firm, segment SIC3, year	firm, segment SIC3, year
Cluster	industry, year	industry, year	industry, year	industry, year	firm, year	firm, year
No. of Obs.	2769	2769	1291	1291	9237	9237
Adj. R-Squared	0.466	0.466	0.453	0.452	0.358	0.358

Table 11. Robustness checks

This table presents the market-wide and within-firm effect of pollution intensity on capital allocation by using different measures of investment and different samples. Panel A shows the result that pollution intensity is defined as the total release to employment, while Panel B shows the results that pollution intensity is defined as the total release to sales. Panel A and Panel C report the results for the industry-level capital investment of single-segment firms. Panel B and D show the results for the within-firm across-industry investment among multi-segment firms. In Panel A and B, pollution intensity is defined as Total Releases/Employment. In Panel C and D, pollution intensity is defined as Total Releases/Sales. Across all panels, Model (1) report the results when we use the abatement-adjusted capital ratio, instead of Capex/Assets. We construct the market-wide abatement-adjusted capital ratio based on this specification:

$$Investment_{j,t} = a_0 + a_1 \times Abatement_{j,t} + A \times X_{j,t} + \varepsilon_{j,t},$$

$$Investment_{j,t}^{adj} = \varepsilon_{j,t} = Investment_{j,t} - (a_0 + a_1 \times Abatement_{j,t} + A \times X_{j,t})$$

where $Investment_{j,t}$ denotes the ratio of capital expenditure to assets for industry j in year t, $Abatement_{j,t}$ denotes the ratio of abatement activity to assets for industry j in year t. The vector $X_{j,t}$ is a set of industry-level control variables, including Tobin's Q, Cash Flow, and Sales Growth. The industry-level variables are value-weighted aggregates from 3-digit industries of plants-level. $Investment_{j,t}^{adj}$, i.e., the residual $\varepsilon_{j,t}$, represents the portion of capital expenditure not explained by environmental abatement activity.

We construct the within-firm abatement-adjusted capital ratio based on this specification:

$$Investment_{i,j,t} = \beta_0 + \beta_1 \times Abatement_{i,j,t} + A \times X_{i,t} + \varepsilon_{i,j,t},$$

$$Investment_{i,j,t}^{adj} = \varepsilon_{i,j,t} = Investment_{i,j,t} - (a_0 + a_1 \times Abatement_{i,j,t} + A \times X_{i,t})$$

where $Investment_{i,j,t}$ denotes the ratio of capital expenditure to assets for firm i's allocation to industry j in year t, $Abatement_{i,j,t}$ denotes the ratio of abatement activity to assets for firm i's allocation to industry j in year t. The vector $X_{i,t}$ is a set of firm-level control variables, including Tobin's Q, Cash Flow, and Sales Growth. $Investment_{i,j,t}^{adj}$, i.e., the residual $\varepsilon_{i,j,t}$, represents the portion of capital expenditure not explained by environmental abatement activity.

Model (2) to (4) report the results that investment is defined as capital expenditure divided by the beginning of year assets (i.e., Assets- Capex + depreciation), the logarithm value of capital expenditure on total assets, and capital expenditure divided by total sales. In Model (5), we use a subsample that excludes those industries that contain less than 5 firms in a year. In Model (6), we restrict the sample to the post-1994 period, when the EPA data is more accurate and comprehensive. Key explanatory variables are standardized to have mean zero and unit standard deviation. The sample period is t = 1990 to 2021. Appendix A provides detailed definitions. *, **, and *** indicate significance levels of 10%, 5%, and 1%, respectively.

Panel A.

	Market-wide capital allocation					
	Abatement-adjusted capital ratio	Capex/Beginning of Year Assets	Log (Capex to assets)	Capex / Sales	Excluding small industry	Year>=1994
	(1)	(2)	(3)	(4)	(5)	(6)
Total releases /Employment	0.232***	0.045***	0.245*	0.306***	0.293***	0.214***
	(4.23)	(3.18)	(1.91)	(3.48)	(4.20)	(2.95)
Control variables	YES	YES	YES	YES	YES	YES
Fixed effect	industry, year	industry, year	industry, year	industry, year	industry, year	industry, year
Cluster	ind, year	ind, year	ind, year	ind, year	ind, year	ind, year
No. of Obs.	1569	1694	1692	1694	1415	1415
Adj. R-Squared	0.466	0.507	0.414	0.377	0.430	0.430

Panel B

	Within-firm capital allocation					
	Abatement-adjusted capital ratio	Capex/Beginning of Year Assets	Log (Capex to assets)	Capex / Sales	Excluding small industry	Year>=1994
	(1)	(2)	(3)	(4)	(5)	(6)
Total releases /Employment	-0.033***	-0.036***	-0.031***	-0.028**	-0.034***	-0.103***
	(-5.68)	(-3.40)	(-3.37)	(-2.43)	(-3.50)	(-3.62)
Control variables	YES	YES	YES	YES	YES	YES
Fixed effect	firm, segment SIC3, year	firm, segment SIC3, year	firm, segment SIC3, year	firm, segment SIC3, year	firm, segment SIC3, year	firm, segment SIC3, year
Cluster	firm, year	firm, year	firm, year	firm, year	firm, year	firm, year
No. of Obs.	8696	8444	8512	8512	7978	7010
Adj. R-Squared	0.373	0.328	0.412	0.369	0.396	0.392

Panel C

	Market-wide capital allocation					
	Abatement-adjusted capital ratio	Capex/Beginning of Year Assets	Log (Capex to assets)	Capex / Sales	Excluding small industry	Year>=1994
	(1)	(2)	(3)	(4)	(5)	(6)
Total releases /Sales	0.194**	0.041***	0.218*	0.279***	0.291***	0.192*
	(2.16)	(2.89)	(1.66)	(2.95)	(4.58)	(1.82)
Control variables	YES	YES	YES	YES	YES	YES
Fixed effect	industry, year	industry, year	industry, year	industry, year	industry, year	industry, year
Cluster	industry, year	industry, year	industry, year	industry, year	industry, year	industry, year
No. of Obs.	1569	1694	1692	1694	1415	1365
Adj. R-Squared	0.465	0.506	0.414	0.376	0.430	0.448

Panel D.

	Within-firm capital allocation					
	Abatement-adjusted capital ratio	Capex/Beginning of Year Assets	Log (Capex to assets)	Capex / Sales	Excluding small industry	Year>=1994
	(1)	(2)	(3)	(4)	(5)	(6)
Total releases /Sales	-0.028***	-0.030***	-0.026***	-0.027***	-0.029***	-0.095***
	(-5.53)	(-3.19)	(-3.18)	(-2.95)	(-3.31)	(-7.92)
Control variables	YES	YES	YES	YES	YES	YES
Fixed effect	firm, segment SIC3, year	firm, segment SIC3, year	firm, segment SIC3, year	firm, segment SIC3, year	firm, segment SIC3, year	firm, segment SIC3, year
Cluster	firm, year	firm, year	firm, year	firm, year	firm, year	firm, year
No. of Obs.	8696	8444	8512	8512	7978	7010
Adj. R-Squared	0.373	0.328	0.412	0.369	0.396	0.392

Online Appendix

Table IN1. The Impact of Paris Agreement

This table reports how Paris Agreement shapes the market-wide and within-firm effect of pollution intensity on capital allocation and abatement allocation. Panel A shows the result of capital allocation, while Panel B shows the results of abatement allocation. The Paris Agreement is dummy variable that equals one if the segment belongs to a firm experience the Paris Agreement in 2015, otherwise zero.

Model (1) and (2) report the results for the industry-level capital investment of single-segment firms. The specification is:

$$Investment_{j,t} = a_0 + a_1 \times Pollution_{j,t-1} \times RegShock_{j,t-1} + a_2 \times Pollution_{j,t-1} + a_3 \times RegShock_{j,t-1} + A \times X_{j,t-1} + \varepsilon_{j,t},$$

where $Investment_{j,t}$ denotes the ratio of net total funding (equity and debt) to assets and the ratio of capital expenditure to assets for industry j in year t, $Pollution_{j,t-1}$ is the industry pollution intensity of the previous year. Key explanatory variables are standardized to have mean zero and unit standard deviation. The vector $X_{j,t-1}$ is a set of industry-level control variables, including Tobin's Q, Cash Flow, and Sales Growth. The industry-level variables are value-weighted aggregates from 3-digit industries of plants-level.

Models (3) and (4) show the results for the within-firm across-industry investment among multi-segment firms. The specification is:

$$Investment_{i,j,t} = \beta_0 + \beta_1 \times Pollution_{i,j,t-1} \times RegShock_{i,j,t-1} + \beta_2 \times Pollution_{i,j,t-1} + \beta_3 \times RegShock_{i,j,t-1} + A \times X_{i,t-1} + \varepsilon_{i,t},$$

where $Investment_{i,j,t}$ denotes the ratio of capital expenditure to assets for firm i's allocation to industry j in year t, $Pollution_{i,j,t-1}$is the pollution intensity of firm i's allocation to industry j in year $t-1$. Key explanatory variables are standardized to have mean zero and unit standard deviation. The vector $X_{i,t-1}$ is a set of firm-level control variables, including Tobin's Q, Cash Flow, and Sales Growth. The sample period is *t* = 1990 to 2021. Appendix A provides detailed definitions. *, **, and *** indicate significance levels of 10%, 5%, and 1%, respectively.

Panel A

	Market-wide capital allocation		Within-firm capital allocation	
	Industry Investment: Capex /Assets		Segment Investment: Capex /Assets	
	(1)	(2)	(3)	(4)
Total releases /Employment * After Paris	0.087		-0.093**	
	(0.28)		(-2.59)	
Total releases /Employment	0.081		-0.040***	
	(0.26)		(-3.47)	
Total releases /Sales * After Paris		0.288		-0.097***
		(0.86)		(-3.17)
Total releases /Sales		-0.101		-0.039***
		(-0.30)		(-3.72)
Tobin's Q	0.414***	0.413***	0.257**	0.260**
	(4.81)	(4.78)	(2.22)	(2.24)
Cash Flow	4.315***	4.253***	6.936***	6.944***
	(3.69)	(3.57)	(5.87)	(5.87)
Sales Growth	0.180	0.179	-0.007*	-0.007*
	(0.40)	(0.40)	(-1.83)	(-1.79)

	firm, segment	firm, segment	firm, segment	firm, segment
Fixed effect	SIC3, year	SIC3, year	SIC3, year	SIC3, year
Cluster	firm, year	firm, year	firm, year	firm, year
No. of Obs.	1682	1682	9718	9718
Adj. R-Squared	0.440	0.441	0.401	0.401

Panel B

	Market-wide abatement allocation		Within-firm abatement allocation	
	Industry Investment: Capex / Assets		Segment Investment: Capex / Assets	
	(1)	(2)	(3)	(4)
Total releases /Employment * After Paris	-0.291		-0.040	
	(-0.06)		(-0.31)	
Total releases /Employment	0.309		-0.230***	
	(0.07)		(-2.99)	
Total releases /Sales * After Paris		1.123		-0.005
		(0.25)		(-0.03)
Total releases /Sales		-1.072		-0.228***
		(-0.23)		(-3.34)
Tobin's Q	-3.718	-3.728	-0.566	-0.564
	(-1.30)	(-1.30)	(-0.83)	(-0.82)
Cash Flow	-3.957	-4.351	-11.331	-11.323
	(-0.17)	(-0.18)	(-1.53)	(-1.53)
Sales Growth	-2.994	-2.995	0.008	0.008
	(-0.68)	(-0.67)	(0.52)	(0.52)
	firm, segment	firm, segment	firm, segment	firm, segment
Fixed effect	SIC3, year	SIC3, year	SIC3, year	SIC3, year
Cluster	firm, year	firm, year	firm, year	firm, year
No. of Obs.	1682	1682	8916	8916
Adj. R-Squared	0.194	0.194	0.452	0.452

Table IN2. Robustness checks for Table 5 Environmental Pressure

	Market-wide capital allocation				Within-firm capital allocation			
	Industry Investment: Capex /Assets				Segment Investment: Capex /Assets			
	KLD Rated	Positive E Score	Positive CSR	Pension Holdings	KLD Rated	Positive E Score	Positive CSR	Pension Holdings
	(1)	(2)	(1)	(2)	(1)	(2)	(1)	(2)
Total releases /Sales*Env Pressure	0.249	-0.113	0.112**	0.265	-0.019***	-0.020***	-0.021***	-0.120***
	(0.99)	(-0.43)	(2.36)	(0.76)	(-5.43)	(-5.43)	(-5.02)	(-3.28)
Total releases /Sales	0.394***	0.420***	0.162	-0.123	-0.023***	-0.020***	-0.023***	-0.037***
	(4.41)	(4.84)	(1.44)	(-0.33)	(-2.85)	(-2.15)	(-2.80)	(-3.46)
Env Pressure	4.338***	4.373***	0.195	0.380**	0.125	0.258	0.258	0.476**
	(3.76)	(3.66)	(0.89)	(2.20)	(1.37)	(1.38)	(1.38)	(2.72)
Control Variables	YES	YES	YES	YES	YES	YES	YES	YES
Fixed effect	industry, year	industry, year	industry, year	industry, year	firm, segment SIC3, year	firm, segment SIC3, year	firm, segment SIC3, year	firm, segment SIC3, year
Cluster	industry, year	industry, year	industry, year	industry, year	firm, year	firm, year	firm, year	firm, year
No. of Obs.	1682.000	1682.000	1682.000	1694	8475	8475	8475	9718
Adj. R-Squared	0.445	0.441	0.441	0.440	0.401	0.401	0.401	0.364

Table IN3. Robustness checks for Table 7 Alternative samples and measures

	Market-wide capital allocation	Market-wide capital allocation		Within-firm capital allocation	
	Industry Investment: Capex / Assets	Industry Investment: Capex / Assets		Segment Investment: Capex / Assets	
	Industries of all firms	Drop firms selling plants	Abatement-adjusted capital ratio	Drop firms selling plants	Abatement-adjusted capital ratio
	(1)	(2)	(3)	(4)	(5)
Total releases /Sales	-0.023	0.142*	0.194**	-0.044***	-0.028***
	(-0.24)	(1.89)	(2.16)	(-3.55)	(-5.53)
Tobin's Q	0.200	0.424***	0.394***	0.195	0.223
	(1.31)	(3.89)	(4.15)	(1.52)	(1.36)
Cash Flow	8.696***	4.151**	4.178**	7.707***	9.161***
	(4.29)	(2.52)	(2.62)	(5.65)	(5.65)
Sales Growth	0.102	-0.169	0.093	-0.008**	-0.104
	(0.17)	(-0.38)	(0.20)	(-2.19)	(-0.40)
Fixed effect	industry, year	industry, year	industry, year	firm, segment SIC3, year	firm, segment SIC3, year
Cluster	industry, year	industry, year	industry, year	firm, year	firm, year
No. of Obs.	2769	1291	1569	9237	8696
Adj. R-Squared	0.466	0.452	0.465	0.358	0.373

Table IN4. The Impact of Selling Plants

This table reports how the action of selling plants shapes the market-wide and within-firm effect of pollution intensity on capital allocation. We employ the firm-level selling of plants dataset from Duchin et al., (2025). We define *Selling Window* as a dummy variable that equals one for firm-year observations within the three-year window surrounding a polluting plant sale, defined as the year prior to, the year of, and the year following the sale (t−1 to t+1, where t = 0 denotes the selling year), and zero otherwise. The sample period is *t* = 1990 to 2021. *, **, and *** indicate significance levels of 10%, 5%, and 1%, respectively.

	Within-firm capital allocation	
	Segment Investment: Capex /Assets	
	(3)	(4)
Total releases /Employment *Selling Window	0.021	
	(0.54)	
Total releases /Employment	-0.043***	
	(-3.86)	
Total releases /Sales * Selling Window		0.024
		(0.45)
Total releases /Sales		-0.039***
		(-3.76)
Selling Window	0.077	0.075
	(0.32)	(0.31)
Tobin's Q	0.261**	0.261**
	(2.25)	(2.25)
Cash Flow	6.951***	6.955***
	(5.89)	(5.89)
Sales Growth	-0.007*	-0.007*
	(-1.81)	(-1.83)
Fixed effect	firm, segment SIC3, year	firm, segment SIC3, year
Cluster	firm, year	firm, year
No. of Obs.	9718	9718
Adj. R-Squared	0.358	0.358

Table IN5. Different specifications

This table presents the within-firm effects of pollution intensity on capital allocation by using different specifications, i.e., alternative fixed effects. Model (1) and (2) report the results by using firm by year fixed effect, while Model (3) and (4) report the results by using firm, and industry by year fixed effects. Key explanatory variables are standardized to have mean zero and unit standard deviation. Appendix A provides detailed definitions. All specifications include firm, industry sic3 and year fixed effects. Standard errors are clustered by firm and year. Robust t-statistics are reported in parentheses. *, **, and *** indicate 10%, 5%, and 1% levels of significance, respectively.

	Within-firm capital allocation			
	Segment Investment: Capex / Assets			
	(1)	(2)	(3)	(4)
Total releases /Employment	-0.020***		-0.034**	
	(-4.65)		(-2.14)	
Total releases /Sales		-0.020***		-0.031**
		(-11.03)		(-2.13)
Tobin's Q			0.258*	0.258*
			(2.01)	(2.01)
Cash Flow			4.473***	4.473***
			(3.83)	(3.83)
Sales Growth			-0.005***	-0.005***
			(-2.83)	(-2.83)
Fixed effect	Firm by year	Firm by year	Firm, Ind by year	Firm, Ind by year
Cluster	firm, year	firm, year	firm, year	firm, year
No. of Obs.	5678	5678	5678	5678
Adj. R-Squared	0.36	0.36	0.36	0.36

Proofs for the Model of Internal Green Reallocation

This appendix provides complete, step-by-step proofs for all lemmas, propositions, and the corollary stated in Appendix B. We use the notation established there: $f^s(K) = A^s K - \frac{b}{2}K^2$ with $f'^s(K) = A^s - bK$; adjustment cost κI_t^2; financing cost $r_t(\theta)$; compliance cost $\tau^s > 0$ per unit of installed capital under environmental pressure (with $\tau^s(\theta) = \tau^s \cdot \mathbf{1}_{\{\theta=H\}}$); $\Delta r_2 \equiv r_2(H) - r_2(L) > 0$; $\bar{r}_2 \equiv \mathbb{E}[r_2(\theta)]$; $\bar{\tau}^s \equiv q\tau^s$.

1. Proof of Lemma 1 (Single-Sector Optimal Investment)

Period-2 problem. Given I_1, the firm observes θ and chooses I_2 to maximize:

$$\max_{I_2} \quad V(\theta) = [A(I_1 + I_2) - b/2\,(I_1 + I_2)^2] - r_1 I_1 - r_2(\theta) I_2 - \tau(\theta)(I_1 + I_2) - \kappa I_1^2 - \kappa I_2^2 \qquad \text{(OA.1)}$$

Substituting $K = I_1 + I_2$ and differentiating with respect to I_2:

$$\frac{\partial V}{\partial I_2} = A - b(I_1 + I_2) - r_2(\theta) - \tau(\theta) - 2\kappa I_2 = 0 \qquad \text{(OA.2)}$$

Collecting terms in I_2:

$$A - bI_1 - bI_2 - r_2(\theta) - \tau(\theta) - 2\kappa I_2 = 0 \qquad \text{(OA.3)}$$

$$A - bI_1 - r_2(\theta) - \tau(\theta) = (2\kappa + b) I_2 \qquad \text{(OA.4)}$$

Solving:

$$I_2^*(\theta) = \frac{A - b\,I_1 - r_2(\theta) - \tau(\theta)}{2\kappa + b} \qquad \text{(OA.5)}$$

The second-order condition is $\frac{\partial^2 V}{\partial I_2^2} = -b - 2\kappa < 0$, confirming a maximum.

Total capital at the optimum:

$$K^*(\theta) = I_1 + I_2^*(\theta) = I_1 + \frac{A - bI_1 - r_2(\theta) - \tau(\theta)}{2\kappa + b}$$
$$= \frac{(2\kappa + b)I_1 + A - bI_1 - r_2(\theta) - \tau(\theta)}{2\kappa + b} \qquad \text{(OA.6)}$$
$$= \frac{2\kappa\, I_1 + A - r_2(\theta) - \tau(\theta)}{2\kappa + b}$$

The difference in period-2 investment across states:

$$I_2^*(L) - I_2^*(H) = \frac{[A - bI_1 - r_2(L)] - [A - bI_1 - r_2(H) - \tau]}{2\kappa + b} = \frac{\Delta r_2 + \tau}{2\kappa + b} > 0 \qquad \text{(OA.7)}$$

so $I_2^*(H) < I_2^*(L)$: the firm invests less in the high-pressure state.

Period-1 problem. At $t = 1$, the firm anticipates $I_2^*(I_1, \theta)$ and solves $\max_{I_1} \mathbb{E}[W(I_1, \theta)]$, where $W(I_1, \theta) \equiv V(I_1, I_2^*(I_1, \theta), \theta)$ is the value function with I_2^* substituted in.

Step 1: Envelope theorem. The total derivative of W with respect to I_1 is:

$$\frac{dW}{dI_1} = \frac{\partial V}{\partial I_1}|_{I_2 = I_2^*} + \frac{\partial V}{\partial I_2}|_{I_2 = I_2^*} \cdot \frac{dI_2^*}{dI_1} \qquad \text{(OA.8)}$$

At $I_2 = I_2^*$, the period-2 FOC ensures $\frac{\partial V}{\partial I_2}|_{I_2^*} = 0$. Therefore the indirect effect vanishes:

$$\frac{dW}{dI_1} = \frac{\partial V}{\partial I_1}|_{I_2 = I_2^*} \qquad \text{(OA.9)}$$

Step 2: Direct partial derivative. Differentiating V with respect to I_1 while holding I_2 fixed (so $\partial K / \partial I_1 = 1$):

$$\frac{\partial V}{\partial I_1}|_{I_2} = A - b(I_1 + I_2) - r_1 - \tau(\theta) - 2\kappa I_1 \qquad \text{(OA.10)}$$

Evaluating at $I_2 = I_2^*$ and using $K^*(\theta) = I_1 + I_2^*$:

$$\frac{dW}{dI_1} = A - bK^*(\theta) - r_1 - \tau(\theta) - 2\kappa I_1 \qquad \text{(OA.11)}$$

Step 3: Substitute $K^*(\theta)$. Substituting $K^*(\theta) = \frac{2\kappa I_1 + A - r_2(\theta) - \tau(\theta)}{2\kappa + b}$:

$$
\begin{aligned}
A - bK^*(\theta) &= A - \frac{b[2\kappa I_1 + A - r_2(\theta) - \tau(\theta)]}{2\kappa + b} \\
&= \frac{(2\kappa + b)A - 2\kappa b I_1 - bA + br_2(\theta) + b\tau(\theta)}{2\kappa + b} \\
&= \frac{2\kappa A - 2\kappa b I_1 + br_2(\theta) + b\tau(\theta)}{2\kappa + b} \\
&= \frac{2\kappa(A - bI_1) + b[r_2(\theta) + \tau(\theta)]}{2\kappa + b}
\end{aligned}
\qquad \text{(OA.12)}
$$

Therefore:

$$
\frac{dW}{dI_1} = \frac{2\kappa(A - bI_1) + b[r_2(\theta) + \tau(\theta)]}{2\kappa + b} - r_1 - \tau(\theta) - 2\kappa I_1 \qquad \text{(OA.13)}
$$

Step 4: Take expectation and set to zero. Setting $\mathbb{E}\left[\frac{dW}{dI_1}\right] = 0$ and denoting $\bar{r}_2 \equiv \mathbb{E}[r_2(\theta)]$, $\bar{\tau} \equiv q\tau$:

$$
\frac{2\kappa(A - bI_1) + b\bar{r}_2 + b\bar{\tau}}{2\kappa + b} - r_1 - \bar{\tau} - 2\kappa I_1 = 0 \qquad \text{(OA.14)}
$$

Step 5: Solve for I_1. Multiply through by $(2\kappa + b)$:

$$
2\kappa(A - bI_1) + b\bar{r}_2 + b\bar{\tau} - (r_1 + \bar{\tau})(2\kappa + b) - 2\kappa I_1(2\kappa + b) = 0 \qquad \text{(OA.15)}
$$

Expand:

$$
2\kappa A - 2\kappa b I_1 + b\bar{r}_2 + b\bar{\tau} - 2\kappa r_1 - br_1 - 2\kappa\bar{\tau} - b\bar{\tau} - 4\kappa^2 I_1 - 2\kappa b I_1 = 0 \qquad \text{(OA.16)}
$$

Collect constant terms:

$$
2\kappa A + b\bar{r}_2 - 2\kappa r_1 - br_1 - 2\kappa\bar{\tau} = 2\kappa(A - \bar{\tau}) + b\bar{r}_2 - (2\kappa + b)r_1 \qquad \text{(OA.17)}
$$

Collect I_1 terms:

$$
-2\kappa b I_1 - 4\kappa^2 I_1 - 2\kappa b I_1 = -(4\kappa b + 4\kappa^2)I_1 = -4\kappa(\kappa + b)I_1 \qquad \text{(OA.18)}
$$

Therefore:

$$2\kappa(A-\bar{\tau})+b\bar{r}_2-(2\kappa+b)r_1=4\kappa(\kappa+b)I_1$$

$$\boxed{I_1^*=\frac{2\kappa(A-\bar{\tau})+b\,\bar{r}_2-(2\kappa+b)\,r_1}{4\kappa(\kappa+b)}} \qquad \text{(OA.19)}$$

Both I_1^* and $I_2^*(\theta)$ are explicit linear functions of the model primitives. 0□

2. Proof of Proposition 1 (Green Paradox in External Markets)

Part (a): Polluting firm. From Lemma 1:

$$I_1^*=\frac{2\kappa(A-\bar{\tau})+b\,\bar{r}_2-(2\kappa+b)\,r_1}{4\kappa(\kappa+b)} \qquad \text{(OA.20)}$$

Since $\bar{r}_2=(1-q)r_2(L)+qr_2(H)$ and $\bar{\tau}=q\tau$, we have:

$$\frac{\partial\bar{r}_2}{\partial q}=r_2(H)-r_2(L)=\Delta r_2, \qquad \frac{\partial\bar{\tau}}{\partial q}=\tau \qquad \text{(OA.21)}$$

Differentiating I_1^* with respect to q:

$$\frac{\partial I_1^*}{\partial q}=\frac{-2\kappa\,\tau+b\,\Delta r_2}{4\kappa(\kappa+b)}=\frac{b\,\Delta r_2-2\kappa\,\tau}{4\kappa(\kappa+b)} \qquad \text{(OA.22)}$$

The denominator $4\kappa(\kappa+b)>0$, so:

$$\frac{\partial I_1^*}{\partial q}>0 \quad\Leftrightarrow\quad b\,\Delta r_2-2\kappa\,\tau>0 \quad\Leftrightarrow\quad b\,\Delta r_2>2\kappa\,\tau \qquad \text{(OA.23)}$$

Dividing both sides by $b>0$:

$$\boxed{\frac{\partial I_1^*}{\partial q}>0 \quad\Leftrightarrow\quad \Delta r_2>\frac{2\kappa}{b}\,\tau} \qquad \text{(OA.24)}$$

Equivalence with the general-f condition. The general condition (for arbitrary concave f) is $\Delta r_2>2\kappa[I_2^*(L)-I_2^*(H)]$. Under the LQ specification, from (OA.7):

$$I_2^*(L)-I_2^*(H)=\frac{\Delta r_2+\tau}{2\kappa+b} \qquad \text{(OA.25)}$$

Substituting:

$$\Delta r_2 > 2\kappa \cdot \frac{\Delta r_2 + \tau}{2\kappa + b} \qquad \text{(OA.26)}$$

Multiply both sides by $(2\kappa + b)$:

$$\begin{gathered}(2\kappa + b)\Delta r_2 > 2\kappa\Delta r_2 + 2\kappa\tau \\ b\,\Delta r_2 > 2\kappa\,\tau\end{gathered} \qquad \text{(OA.27)}$$

which is exactly the LQ green paradox condition.

Economic interpretation. From Lemma 1, the single-sector firm's optimal investment satisfies $I_2^*(H) < I_2^*(L)$ (equation (OA.7)). The green paradox ($\partial I_1^* / \partial q > 0$) arises when the financing-cost increase Δr_2 is large relative to the compliance cost τ. The financing-cost channel drives the paradox: a larger Δr_2 raises the expected marginal product of early investment by depressing period-2 capital in the high-pressure state, making front-loading attractive. The compliance cost τ works against front-loading, and the paradox arises only when Δr_2 is large enough relative to τ.

Part (b): Clean firm benchmark. As a benchmark, consider a firm in a clean industry with state-independent financing cost r_2^g and no compliance cost ($\tau = 0$). Its payoff is:

$$V^g(\theta) = (AK - b/2\,K^2) - r_1 I_1 - r_2^g I_2 - \kappa I_1^2 - \kappa I_2^2 \qquad \text{(OA.28)}$$

The FOC $A - b(I_1 + I_2) - r_2^g - 2\kappa I_2 = 0$ is identical to the dirty firm's with $r_2(\theta) = r_2^g$ and $\tau(\theta) = 0$:

$$I_2^{g*} = \frac{A - bI_1 - r_2^g}{2\kappa + b} \qquad \text{(OA.29)}$$

Because r_2^g and $\tau = 0$ are state-independent, I_2^{g*} does not depend on θ: $I_2^{g*}(H) = I_2^{g*}(L) \equiv I_2^{g*}$. Applying the envelope theorem exactly as in Lemma 1, with $\bar{\tau} = 0$ and $\bar{r}_2 = r_2^g$:

$$I_1^{g*} = \frac{2\kappa A + b\, r_2^g - (2\kappa + b)\, r_1}{4\kappa(\kappa + b)} \qquad \text{(OA.30)}$$

No probability q appears—the green firm's investment is fully deterministic. Applying the derivative formula with $\Delta r_2^g = 0$ and $\tau = 0$:

$$\frac{\partial I_1^{g*}}{\partial q} = \frac{b \cdot 0 - 2\kappa \cdot 0}{4\kappa(\kappa + b)} = 0 \qquad \text{(OA.31)}$$

The green paradox condition $b\,\Delta r_2 > 2\kappa\,\tau$ becomes $0 > 0$, which is false. Both channels are exactly zero for the green firm, confirming the paradox is specific to polluting firms. 0□

3. Proof of Lemma 2 (Two-Sector Optimal Investment)

The two-sector firm's headquarters maximizes:

$$V(\theta) = \sum_{s\in\{C,P\}} [f^s(K^s) - \tau^s(\theta)K^s - \kappa(I_1^s)^2 - \kappa(I_2^s)^2] - r_1(I_1^C + I_1^P) - r_2(\theta)(I_2^C + I_2^P) \qquad \text{(OA.32)}$$

where $K^s = I_1^s + I_2^s$ for each sector $s \in \{C, P\}$.

Period-2 problem. Given (I_1^C, I_1^P), the firm observes θ and solves:

$$\max_{I_2^C, I_2^P} \quad V(\theta) = \sum_{s\in\{C,P\}} [f^s(I_1^s + I_2^s) - \tau^s(\theta)(I_1^s + I_2^s) - \kappa(I_1^s)^2 - \kappa(I_2^s)^2] - r_1(I_1^C + I_1^P) - r_2(\theta)(I_2^C + I_2^P) \qquad \text{(OA.33)}$$

Step 1: Separability. The objective is additively separable across sectors up to the common financing cost $r_2(\theta)$, which enters linearly. Differentiating with respect to I_2^s for sector $s \in \{C, P\}$:

$$\frac{\partial V}{\partial I_2^s} = f'^s(I_1^s + I_2^s) - r_2(\theta) - \tau^s(\theta) - 2\kappa I_2^s = 0 \qquad \text{(OA.34)}$$

The FOC for I_2^C does not involve I_2^P and vice versa, so the two sectors' period-2 problems are independent.

Step 2: Solve with LQ specification. Substituting $f'^s(K^s) = A^s - bK^s = A^s - b(I_1^s + I_2^s)$:

$$A^s - b(I_1^s + I_2^s) - r_2(\theta) - \tau^s(\theta) - 2\kappa I_2^s = 0 \qquad \text{(OA.35)}$$

Collecting terms in I_2^s:

$$A^s - bI_1^s - r_2(\theta) - \tau^s(\theta) = bI_2^s + 2\kappa I_2^s = (2\kappa + b)I_2^s \qquad \text{(OA.36)}$$

$$\boxed{I_2^{s*}(\theta) = \frac{A^s - b\,I_1^s - r_2(\theta) - \tau^s(\theta)}{2\kappa + b}} \qquad \text{(OA.37)}$$

The second-order condition is $\frac{\partial^2 V}{\partial (I_2^s)^2} = -b - 2\kappa < 0$, confirming a maximum.

Total capital:

$$K^{s*}(\theta) = I_1^s + I_2^{s*}(\theta) = I_1^s + \frac{A^s - bI_1^s - r_2(\theta) - \tau^s(\theta)}{2\kappa + b}$$
$$= \frac{2\kappa\, I_1^s + A^s - r_2(\theta) - \tau^s(\theta)}{2\kappa + b} \qquad \text{(OA.38)}$$

Period-1 problem. At $t = 1$, headquarters anticipates $I_2^{s*}(I_1^s, \theta)$ and solves:

$$\max_{I_1^C, I_1^P} \quad \mathbb{E}[W(I_1^C, I_1^P, \theta)] \quad \text{subject to} \quad I_1^C + I_1^P \le B \qquad \text{(OA.39)}$$

where $W \equiv V(I_1^C, I_1^P, I_2^{C*}, I_2^{P*}, \theta)$ is the value function with optimal period-2 choices substituted in.

Step 3: Lagrangian. Form the Lagrangian with multiplier $\mu \ge 0$:

$$\mathcal{L} = \mathbb{E}[W(I_1^C, I_1^P, \theta)] + \mu(B - I_1^C - I_1^P) \qquad \text{(OA.40)}$$

with complementary slackness $\mu(B - I_1^C - I_1^P) = 0$.

Step 4: Total derivative decomposition. For each sector $s \in \{C, P\}$, the choice of I_1^s affects W both directly and indirectly through $I_2^{s*}(I_1^s, \theta)$:

$$\frac{dW}{dI_1^s} = \underbrace{\frac{\partial W}{\partial I_1^s}|_{I_2^s \text{ fixed}}}_{\text{direct effect}} + \underbrace{\frac{\partial W}{\partial I_2^s}|_{I_1^s \text{ fixed}} \cdot \frac{dI_2^{s*}}{dI_1^s}}_{\text{indirect effect through } I_2^{s*}} \qquad \text{(OA.41)}$$

Note that I_2^{s*} depends only on I_1^s (not on the other sector's I_1), because the period-2 problem is separable.

Step 5: Envelope theorem. At $I_2^s = I_2^{s*}$, the period-2 FOC ensures:

$$\frac{\partial W}{\partial I_2^s}|_{I_2^{s*}} = f'^s(K^{s*}) - r_2(\theta) - \tau^s(\theta) - 2\kappa I_2^{s*} = 0 \qquad \text{(OA.42)}$$

The indirect effect vanishes for each sector, and the total derivative reduces to:

$$\frac{dW}{dI_1^s} = \frac{\partial W}{\partial I_1^s}|_{I_2^{s*}} \qquad \text{(OA.43)}$$

Step 6: Direct partial derivative. Differentiating W with respect to I_1^s while holding I_2^s fixed (so $\partial K^{s*} / \partial I_1^s = 1$):

$$\frac{\partial W}{\partial I_1^s}|_{I_2^{s*}} = f'^s(K^{s*}(\theta)) - r_1 - \tau^s(\theta) - 2\kappa I_1^s \qquad \text{(OA.44)}$$

Step 7: Period-1 FOCs. Differentiating $\mathcal{L}$ with respect to I_1^s and setting to zero:

$$\mathbb{E}\left[\frac{dW}{dI_1^s}\right] - \mu = 0 \quad \Rightarrow \quad \mathbb{E}[f'^s(K^{s*}(\theta))] - r_1 - \bar{\tau}^s - 2\kappa I_1^s - \mu = 0 \qquad \text{(OA.45)}$$

Writing out each sector:

$$\text{Core:} \quad \mathbb{E}[f'^C(K^{C*}(\theta))] - r_1 - \bar{\tau}^C - 2\kappa I_1^C - \mu = 0 \qquad \text{(OA.46)}$$

$$\text{Peripheral:} \quad \mathbb{E}[f'^P(K^{P*}(\theta))] - r_1 - \bar{\tau}^P - 2\kappa I_1^P - \mu = 0 \qquad \text{(OA.47)}$$

Step 8: Substitute LQ marginal product. Under the LQ specification, $f'^{S}(K^{S*}) = A^S - bK^{S*}$.

Using $K^{S*}(\theta) = \frac{2\kappa I_1^S + A^S - r_2(\theta) - \tau^S(\theta)}{2\kappa + b}$:

$$f'^{S}(K^{S*}) = A^S - b \cdot \frac{2\kappa I_1^S + A^S - r_2(\theta) - \tau^S(\theta)}{2\kappa + b}$$
$$= \frac{2\kappa(A^S - bI_1^S) + b[r_2(\theta) + \tau^S(\theta)]}{2\kappa + b} \qquad \text{(OA.48)}$$

Taking expectations:

$$\mathbb{E}[f'^{S}(K^{S*})] = \frac{2\kappa(A^S - bI_1^S) + b\bar{r}_2 + b\bar{\tau}^S}{2\kappa + b} \qquad \text{(OA.49)}$$

Substituting into the FOC (OA.45):

$$\frac{2\kappa(A^S - bI_1^S) + b\bar{r}_2 + b\bar{\tau}^S}{2\kappa + b} - r_1 - \bar{\tau}^S - 2\kappa I_1^S - \mu = 0 \qquad \text{(OA.50)}$$

Step 9: Solve for I_1^S. Multiply through by $(2\kappa + b)$:

$$2\kappa(A^S - bI_1^S) + b\bar{r}_2 + b\bar{\tau}^S - (r_1 + \bar{\tau}^S + \mu)(2\kappa + b) - 2\kappa I_1^S(2\kappa + b) = 0 \qquad \text{(OA.51)}$$

Expand:

$$2\kappa A^S - 2\kappa b I_1^S + b\bar{r}_2 + b\bar{\tau}^S - 2\kappa r_1 - 2\kappa\bar{\tau}^S - 2\kappa\mu - br_1 - b\bar{\tau}^S - b\mu - 4\kappa^2 I_1^S - 2\kappa b I_1^S$$
$$= 0 \qquad \text{(OA.52)}$$

Collect constant terms (the $b\bar{\tau}^S$ terms cancel):

$$2\kappa A^S + b\bar{r}_2 - 2\kappa\bar{\tau}^S - (2\kappa + b)r_1 - (2\kappa + b)\mu$$
$$= 2\kappa(A^S - \bar{\tau}^S) + b\bar{r}_2 - (2\kappa + b)(r_1 + \mu) \qquad \text{(OA.53)}$$

Collect I_1^S terms:

$$-2\kappa b I_1^S - 4\kappa^2 I_1^S - 2\kappa b I_1^S = -4\kappa(\kappa + b)I_1^S \qquad \text{(OA.54)}$$

Therefore:

$$I_1^{s*} = \frac{2\kappa(A^s - \bar{\tau}^s) + b\bar{r}_2 - (2\kappa + b)(r_1 + \mu)}{4\kappa(\kappa + b)} \qquad \text{(OA.55)}$$

Step 10: Solve for μ. When the budget constraint binds, $I_1^C + I_1^P = B$. Summing (OA.55) for $s = C$ and $s = P$:

$$B = I_1^{C*} + I_1^{P*} = \frac{2\kappa[(A^C - \bar{\tau}^C) + (A^P - \bar{\tau}^P)] + 2b\bar{r}_2 - 2(2\kappa + b)(r_1 + \mu)}{4\kappa(\kappa + b)} \qquad \text{(OA.56)}$$

Multiply both sides by $4\kappa(\kappa + b)$:

$$4\kappa(\kappa + b)B = 2\kappa(A^C + A^P - \bar{\tau}^C - \bar{\tau}^P) + 2b\bar{r}_2 - 2(2\kappa + b)(r_1 + \mu) \qquad \text{(OA.57)}$$

Solve for μ:

$$\begin{aligned} 2(2\kappa + b)\mu &= 2\kappa(A^C + A^P - \bar{\tau}^C - \bar{\tau}^P) + 2b\bar{r}_2 - 2(2\kappa + b)r_1 - 4\kappa(\kappa + b)B \\ \mu &= \frac{\kappa(A^C + A^P - \bar{\tau}^C - \bar{\tau}^P) + b\bar{r}_2 - (2\kappa + b)r_1 - 2\kappa(\kappa + b)B}{2\kappa + b} \end{aligned} \qquad \text{(OA.58)}$$

Step 11: Closed-form allocation. From (OA.55), the difference $I_1^{C*} - I_1^{P*}$ eliminates μ:

$$I_1^{C*} - I_1^{P*} = \frac{2\kappa[(A^C - \bar{\tau}^C) - (A^P - \bar{\tau}^P)]}{4\kappa(\kappa + b)} = \frac{(A^C - A^P) + (\bar{\tau}^P - \bar{\tau}^C)}{2(\kappa + b)} \qquad \text{(OA.59)}$$

Combined with $I_1^{C*} + I_1^{P*} = B$:

$$\begin{aligned} I_1^{C*} &= \frac{B}{2} + \frac{I_1^{C*} - I_1^{P*}}{2} = \frac{B}{2} + \frac{(A^C - A^P) + (\bar{\tau}^P - \bar{\tau}^C)}{4(\kappa + b)} \\ I_1^{P*} &= \frac{B}{2} - \frac{(A^C - A^P) + (\bar{\tau}^P - \bar{\tau}^C)}{4(\kappa + b)} \end{aligned} \qquad \text{(OA.60)}$$

In boxed form:

$$\boxed{\begin{aligned} I_1^{C*} &= \frac{B}{2} + \frac{(A^C - A^P) + (\bar{\tau}^P - \bar{\tau}^C)}{4(\kappa + b)} \\ I_1^{P*} &= \frac{B}{2} - \frac{(A^C - A^P) + (\bar{\tau}^P - \bar{\tau}^C)}{4(\kappa + b)} \end{aligned}} \qquad \text{(OA.61)}$$

0□

4. Proof of Proposition 2 (Internal Green Reallocation)

Comparative statics. From Lemma 2:

$$I_1^{C*} = \frac{B}{2} + \frac{(A^C - A^P) + (\bar{\tau}^P - \bar{\tau}^C)}{4(\kappa + b)} \qquad \text{(OA.62)}$$

$$I_1^{P*} = \frac{B}{2} - \frac{(A^C - A^P) + (\bar{\tau}^P - \bar{\tau}^C)}{4(\kappa + b)} \qquad \text{(OA.63)}$$

The parameters A^C, A^P, b, κ, and B are independent of q. Only the expected compliance costs depend on q:

$$\bar{\tau}^s = q\tau^s \quad \Rightarrow \quad \frac{\partial \bar{\tau}^s}{\partial q} = \tau^s > 0 \qquad \text{(OA.64)}$$

Differentiating I_1^{C*} with respect to q:

$$\frac{\partial I_1^{C*}}{\partial q} = \frac{1}{4(\kappa + b)}\left(\frac{\partial \bar{\tau}^P}{\partial q} - \frac{\partial \bar{\tau}^C}{\partial q}\right) = \frac{\tau^P - \tau^C}{4(\kappa + b)} \qquad \text{(OA.65)}$$

Differentiating I_1^{P*} with respect to q:

$$\frac{\partial I_1^{P*}}{\partial q} = -\frac{1}{4(\kappa + b)}\left(\frac{\partial \bar{\tau}^P}{\partial q} - \frac{\partial \bar{\tau}^C}{\partial q}\right) = -\frac{\tau^P - \tau^C}{4(\kappa + b)} \qquad \text{(OA.66)}$$

In boxed form:

$$\boxed{\begin{aligned} \frac{\partial I_1^{C*}}{\partial q} &= \frac{\tau^P - \tau^C}{4(\kappa + b)} \geq 0 \\ \frac{\partial I_1^{P*}}{\partial q} &= -\frac{\tau^P - \tau^C}{4(\kappa + b)} \leq 0 \end{aligned}} \qquad \text{(OA.67)}$$

Since $\tau^P > \tau^C > 0$ by assumption, we have $\tau^P - \tau^C > 0$ and $4(\kappa + b) > 0$. Therefore $\partial I_1^{C*} / \partial q > 0$ and $\partial I_1^{P*} / \partial q < 0$.

Key observation: Δr_2 does not appear. Neither derivative depends on Δr_2. To see why, note from (OA.55) that $\bar{r}_2$ enters the individual investment level I_1^{S*} through the term $b\bar{r}_2/[4\kappa(\kappa + b)]$. But this term is *common across sectors*—it does not carry a sector superscript. When we take the difference $I_1^{C*} - I_1^{P*}$, it cancels. And because $I_1^{C*} + I_1^{P*} = B$ is fixed, any common shift in the level is fully absorbed by the budget constraint through the shadow cost μ. The financing cost $r_2(\theta)$ affects how much the firm *wants* to invest in aggregate, but not how it *allocates* investment across sectors.

Unconditional reallocation and strategic pruning. The result $\partial I_1^{P*}/\partial q < 0$ holds unconditionally—it does not depend on any parameter region. In contrast, the single-sector green paradox requires $b\,\Delta r_2 > 2\kappa\,\tau$. Because the budget constraint binds ($I_1^C + I_1^P = B$), any reduction in peripheral investment is exactly offset by an increase in core investment: $\partial I_1^{C*}/\partial q = -\partial I_1^{P*}/\partial q > 0$. The condition $A^C > A^P$ ensures that the core receives more than half the budget (Lemma 2), making the pruning strategy optimal. The result $\partial I_1^P/\partial q < 0 < \partial I_1^C/\partial q$ holds whenever $\tau^P > \tau^C$, which is guaranteed by the assumption that the peripheral sector is more polluting. 0□

5. Proof of Corollary 2

We need to show that both conditions can hold simultaneously:

$$\text{Single-sector green paradox:} \quad \frac{\partial I_1^*}{\partial q} > 0 \quad \Leftrightarrow \quad b\,\Delta r_2 > 2\kappa\,\tau \qquad \text{(OA.68)}$$

$$\text{Two-sector no green paradox:} \quad \frac{\partial I_1^{P*}}{\partial q} \leq 0 \quad \Leftrightarrow \quad \tau^P \geq \tau^C \qquad \text{(OA.69)}$$

Condition (OA.69) holds by assumption ($\tau^P > \tau^C > 0$) for *all* values of Δr_2, because Δr_2 does not appear in the two-sector derivative.

Condition (OA.68) can be satisfied by choosing Δr_2 sufficiently large. Specifically, for any $b > 0,\ \kappa > 0,\ \tau > 0$, the condition holds whenever:

$$\Delta r_2 > \frac{2\kappa}{b}\tau \qquad \text{(OA.70)}$$

Since $\frac{2\kappa}{b}\tau$ is a finite positive number, there exist infinitely many values of Δr_2 satisfying this inequality.

Therefore, for any $\Delta r_2 > \frac{2\kappa}{b}\tau$, both conditions hold simultaneously. The set of such parameters is:

$$\left\{(b, \kappa, \Delta r_2, \tau, \tau^C, \tau^P): b > 0,\ \kappa > 0,\ \tau^P > \tau^C > 0,\ \Delta r_2 > \frac{2\kappa}{b}\tau\right\} \qquad \text{(OA.71)}$$

which is an open set in the parameter space (not knife-edge). 0□

6. Proof of Corollary 3 (Compliance Cost and Pollution Type)

From Lemma 2, the closed-form allocation is:

$$I_1^{P*} = \frac{B}{2} - \frac{(A^C - A^P) + (\bar{\tau}^P - \bar{\tau}^C)}{4(\kappa + b)} \qquad \text{(OA.72)}$$

Differentiating with respect to $\bar{\tau}^P$ (holding $\bar{\tau}^C$ fixed):

$$\frac{\partial I_1^{P*}}{\partial \bar{\tau}^P} = -\frac{1}{4(\kappa + b)} < 0 \qquad \text{(OA.73)}$$

Since $\bar{\tau}^P = q\tau^P$ is increasing in τ^P, higher compliance costs in the peripheral sector unambiguously reduce investment in that sector. Because τ^P is increasing in the toxicity and on-site intensity of the sector's pollution (by the model's assumption on the compliance cost structure), sectors with more toxic on-site pollution face stronger divestment pressure. 0□

7. Proof of Corollary 1 (Financial Constraints Activate Reallocation)

From the period-1 FOC for each sector (equation (OA.45)):

$$\mathbb{E}[f'^s(K^{s*})] - r_1 - \bar{\tau}^s - 2\kappa I_1^s = \mu \qquad \text{(OA.74)}$$

When the budget constraint is slack ($\mu = 0$), each sector is optimized independently: the firm invests in each sector until its net marginal benefit equals zero. There is no direct competition for funds, and reallocation operates only through the compliance-cost channel within each sector's own FOC.

When the budget constraint binds ($\mu > 0$), each dollar allocated to one sector has an opportunity cost of μ in the other sector. Because the peripheral sector has both lower marginal productivity ($A^P < A^C$, so $f'^P < f'^C$ at comparable capital) and higher compliance cost ($\tau^P > \tau^C$), its net marginal benefit $\mathbb{E}[f'^P] - \bar{\tau}^P$ is lower than the core's $\mathbb{E}[f'^C] - \bar{\tau}^C$. To equate both FOCs to the same μ, the peripheral sector must receive less investment ($I_1^P < I_1^C$). The magnitude of this reallocation is:

$$I_1^{C*} - I_1^{P*} = \frac{(A^C - A^P) + (\bar{\tau}^P - \bar{\tau}^C)}{2(\kappa + b)} \qquad \text{(OA.75)}$$

which is strictly positive when $A^C > A^P$ or $\bar{\tau}^P > \bar{\tau}^C$ (or both). When $\mu = 0$, this gap still exists through the individual FOCs, but the budget constraint introduces the additional force that every unit invested in P directly displaces a unit that could go to C, amplifying the reallocation. The shadow cost μ scales with the scarcity of internal funds (higher when B is tighter relative to desired aggregate investment), so financial constraints amplify internal green reallocation. 0□