Counterproductive Sustainable Investing: The Impact Elasticity of Brown and Green Firms *

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Abstract

We develop a new measure of impact elasticity, defined as the change in environmental impact of a firm due to a change in its cost of capital. We show empirically that a reduction in financing costs for firms that are already green leads to small improvements in impact at best. In contrast, increasing financing costs for brown firms leads to large negative changes in firm impact. Thus, sustainable investing that directs capital away from brown firms and toward green firms may be counterproductive in that it makes brown firms more brown without making green firms more green. We also show that brown firms face very weak financial incentives to become more green. Due to a mistaken focus on *percentage* reductions in emissions, the sustainable investing movement primarily rewards green firms for economically trivial reductions in their already low levels of emissions.

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A wise man gets more use from his enemies than a fool from his friends. -Baltasar Gracian

I. Introduction

Sustainable investing has exploded in popularity, with $35 trillion in global assets in 2020 expected to grow to one third of all assets under management by 2025.[1] While a variety of tactics have been employed, the dominant sustainable investing strategy involves making investments in firms that are perceived to be "green" (positive environmental impact) and avoiding investments in firms that are perceived to be "brown" (negative environmental impact).[2] To the extent that sustainable investing can change firm financing conditions, it rewards green firms by lowering their cost of capital and punishes brown firms by raising their cost of capital. A commonly stated goal of sustainable investors is to facilitate a green economic transition, whereby their investments motivate all firms to become more green while minimizing economic loss or even while encouraging economic growth. The success of the sustainable investing movement in achieving this green transition goal depends critically on how firms alter their behavior in response to changing financing conditions. In this paper, we develop a new measure of "impact elasticity," defined as the change in environmental impact of a company due to a change in its cost of capital. Without knowing the impact elasticities of green and brown firms, it is unclear which and how firms should be targeted by sustainable investors.

This paper shows that, if the dominant sustainable investing strategy of directing capital away from brown firms toward green firms succeeds in changing financing costs, such a strategy would be counterproductive relative to a green transition goal, in that it would make brown firms more brown without making green firms more green. We show empirically that firms that are considered green based on their greenhouse gas emissions per unit of output have little scope for further improvement in their impact. Brown firms exhibit large negative impact elasticities—they become substantially less brown in response to easier access to capital and more brown if pushed toward financial distress. Furthermore, we show that the dominant sustainable investing strategy provides very weak financial incentives for brown firms to become more green. Due to a mistaken focus on *percentage* changes in emissions, sustainable investors primarily reward green firms for economically trivial reductions in

[1] See https://www.bloomberg.com/company/press/esg-may-surpass-41-trillion-assets-in-2022-but-not-without-challenges-finds-bloomberg-intelligence. We use "sustainable investing" as an umbrella term to refer to investment strategies that seek to improve firm environmental impact on society. Commonly used terms for such investments are green investing, socially responsible investments (SRI), environmental, social and governance (ESG) investing, ethical investing, and corporate social responsibility (CSR) investing, amongst others.

[2] Examples of such strategies include screening, where brown firms are excluded from sustainable portfolios, as well as ESG integration, where sustainability metrics are used in portfolio construction leading to an overweight in green firms and underweight in brown firms.

their already low emissions. Brown firms are substantially underweighted by sustainable investors, even if the brown firms substantially reduce emissions or are relatively green within their industry.

A growing body of recent empirical research shows that sustainable investors have already succeeded in raising the cost of capital for brown firms relative to green firms (see, e.g., Chava (2014), van der Beck (2021), Kacperczyk and Peydró (2022), Pástor et al. (2022), Aron-Dine et al. (2023), and Green and Vallee (2022)). In particular, Gormsen et al. (2023) use quarterly earnings conference call transcripts to show that managers of brown firms perceive that their cost of capital has increased by 2.6 percentage points relative to green firms over the period 2016 to 2021. However, there is active debate about whether other investors can offset the impact of sustainable investment flows (Teoh et al. (1999) and Berk and van Binsbergen (2021), and for a general framework, see Gabaix and Koijen (2021)). In this paper, we do not take a strong stand on how much sustainable investing has already altered firms' cost of capital. Rather, we believe that with $35 trillion in committed assets, it is important to consider what would happen if the movement succeeds. We show that creating a wedge in the cost of capital between brown and green firms may actually be counterproductive for sustainable investors who seek to transition firms to becoming more green.

A simple case study may help illustrate the intuition of our paper. Travelers is an insurance firm in the S&P 500 that looks spectacular on environmental, social, and governance (ESG) metrics. Travelers widely advertises its low greenhouse gas emissions. In 2021, it emitted 33,477 metric tons of carbon, about 1 ton per million dollars of revenue.[3] At the opposite extreme lies Martin Marietta Materials, another S&P 500 firm that supplies heavy building materials. Among ESG rating providers, Martin Marietta is generally considered poor. In 2021, it emitted approximately 5.1 million tons of carbon, corresponding to roughly 1,000 tons per million dollars of revenue.[4] Relative to Travelers, Martin Marietta has 1,000 times as much emissions intensity, measured as emissions scaled by revenue.

The most common sustainable investing strategy dictates that investors should invest in Travelers and avoid Martin Marietta. With that said, if money flows toward Travelers allowing further investments in green projects at subsidized rates, where would it go? If Travelers cut emissions by 100%, it would be equivalent to Martin Marietta cutting its emissions by a mere 0.1%. As an insurance firm, Travelers is also very unlikely to develop new green technology that could be adopted by other firms or to manufacture building materials in a manner more environmentally friendly than Martin Mari-

[3] https://sustainability.travelers.com/iw-documents/sustainability/Travelers_ESGAnalystData2021.pdf

[4] https://mcdn.martinmarietta.com/assets/sustainability/flip/sustainability2021-f/index.html

etta currently does. On the other hand, Martin Marietta has the capability of becoming much more green or brown. While the company emits a large amount of carbon, it does so after having made costly investments in new clean production methods to cut its emissions per ton of cement from 0.84 in 2016 to 0.77 in 2019. Conversely, if the market forced Martin Marietta to worry about its short-term survival, the company could double down on its existing brown projects which deliver more front-loaded cash flows. Simply reversing its efficiencies per dollar since 2016 would result in an increase in emissions of approximately one million tons, equal to 30 times Travelers' annual level of emissions.

In our empirical analysis, we show that the intuition of this example is reflective of the broader data. We measure firm environmental impact using greenhouse gas (e.g., carbon) emissions. The importance of emissions for sustainable investors is reflected in recent SEC communications concerning the mandatory disclosure of emissions in the portfolio holdings of all funds that consider environmental factors.[5] Indeed, a recent cover story in *The Economist* argued that emissions are so important that they should be the sole focus of sustainable investors.[6] We measure firm emissions as raw emissions scaled by firm output. This is a standardized measure that is commonly used by sustainable investors. It has the benefits of being comparable across firm sizes and of capturing the trade-off between emissions and output inherent in a green transition goal.

We begin by showing that brown firms have much higher levels of emissions and year-to-year variability than green firms. Variability provides an estimate of an upper bound on the absolute value of a firm's impact elasticity; variability that is close to zero suggests that the impact elasticity is also close to zero. We divide firms into quintiles by their emissions intensity (defined as scope 1 and scope 2 emissions scaled by revenue, hereafter referred to as "emissions" for brevity) in the previous year, with quintiles 1 and 5 representing brown and green firms, respectively. The average brown firm has 261 times as much emissions as the average green firm, and experiences approximately 150 times larger absolute changes in emissions from year to year, suggesting that brown firms have much greater scope to change their environmental impact.

Next, we examine the impact elasticity of green and brown firms. To obtain sufficient statistical

[5] "ESG-focused funds that consider environmental factors... would be required to disclose the carbon footprint and the weighted average carbon intensity of their portfolio. The requirements are designed to meet demand from investors seeking environmentally focused fund investments for consistent and comparable quantitative information regarding the GHG emissions associated with their portfolios and to allow investors to make decisions in line with their own ESG goals and expectations." https://www.sec.gov/files/ia-6034-fact-sheet.pdf

[6] The article states, "The environment is an all-encompassing term, including biodiversity, water scarcity and so on. By far the most significant danger is from emissions, particularly those generated by carbon-belching industries. Put simply, the e should stand not for environmental factors, but for emissions alone." https://www.economist.com/leaders/2022/07/21/esg-should-be-boiled-down-to-one-simple-measure-emissions

power, we consider a broad class of shocks to firms' cost of capital without restricting our attention to changes in financing costs due to sustainable investing. The underlying assumption is that, if the dominant sustainable investing strategy succeeds in altering firms' financing costs, firms would react in a similar fashion as they react to other changes in their financing costs. We explore potential violations of this assumption later in this paper.

Across a variety of tests, we find that brown firms have large negative impact elasticities, while green firms have impact elasticities closer to zero. First, brown firms show greater reductions in their emissions after improvements in their financial performance. Stronger past returns ease financial constraints and lower the firm's cost of capital. To establish causality, we examine the relation between firm emissions and the firm's industry return in the previous year, calculated excluding the focal firm. The intuition is that industry return shocks strongly affect firm financing costs, but individual firm choices of emissions should not affect industry returns. We find that brown firms are much more elastic to industry shocks than green firms. Because firm investment choices can take time to fully manifest as changes in emissions, we also conduct tests at longer horizons. We find that changes in brown firm emissions intensity are persistent and larger at longer horizons; they do not appear to be driven by short-term fluctuations in output or stickiness in raw emissions. Second, we examine how firm emissions respond to financial distress, as proxied by interest coverage, Altman Z-scores, or industry performance in the lowest decile within our sample. We find that brown firms react to financial distress by increasing their emissions, whereas green firms exhibit a much smaller response, sometimes in the opposite direction.

Next, we present three tests to isolate a financial channel operating through the cost of capital, as distinct from potentially correlated productivity shocks. First, we examine changes in a firm's implied cost of capital (ICC), a measure that captures the portion of past returns that is due to changes in the cost of capital rather than changes in cash flow expectations. Across a variety of ICC measures, we find that brown firms exhibit large negative impact elasticities, whereas green firms exhibit elasticities close to zero. Second, to identify the role of financial constraints, we assess whether firms that are more leveraged react differently to industry productivity shocks. The cost of capital of highly leveraged firms should be more sensitive to the same productivity shock. Consistent with this prediction, we find that highly leveraged brown firms increase emissions the most after negative industry shocks. Third, we exploit exogenous variation in firms' cost of capital induced by variation in demand for dividend payments, following techniques introduced in Hartzmark and Solomon (2013, 2019). We find that changes in the cost of capital induced by dividend demand affect the emissions of high-dividend-yield brown firms significantly more than emissions of green firms and other brown firms.

Our findings of a large negative impact elasticity for brown firms and a close-to-zero one for green firms are consistent with basic corporate finance theory. Brown firms likely face a choice between dark-brown investment projects (e.g., continuing existing high-pollution production, or cutting corners on pollution abatement) and light-brown investments (e.g., shifting to cleaner production or green energy). Because the light-brown project entails a departure from existing production methods, it likely requires investment in new capital which costs more up front and delivers back-loaded cash flows compared to the dark-brown project. Financial distress or an increase in the cost of capital will make short-term cash flows more attractive relative to long-run cash flows. Intuitively, an increase in the cost of capital is equivalent to a higher discount rate for the future. Thus, an increase in the cost of capital causes the dark-brown project to look relatively more attractive, leading brown firms to have a negative impact elasticity.[7] An increase in the cost of capital will similarly cause green firms to prefer projects that generate short-term cash flows. However, green firms operate in industries (e.g., insurance for Travelers) where they cannot generate substantial environmental externalities regardless of which projects they choose to pursue, leading green firms to have impact elasticities close to zero.

So far, we have shown that the direct effect of an increase in the cost of capital is to make brown firms more brown. Next, we investigate whether sustainable investors provide incentives for brown firms to become more green. Specifically, managers of brown firms may choose to become more green if sustainable investors reward them by lowering their cost of capital or increasing their share price.

Although a strategy targeted at incentivizing brown firms to become more green is promising, we show that such incentives have not been provided in practice. Sustainable investment funds indeed reward firms that have improved their impact over the past several years, consistent with best practices modeled by Oehmke and Opp (2022). However, changes in impact are measured in the wrong units. Sustainable investors appear to suffer from a proportional thinking bias (Tversky and Kahneman (1981) and Shue and Townsend (2021)) in which they reward firms with large *percentage* reductions in emissions rather than large *level* reductions in emissions. Influential ESG environmental ratings similarly reward percentage reductions in emissions rather than level reductions in emissions.

[7] This intuition is similar to the model in Lanteri and Rampini (2023), which shows that financial constraints cause firms to choose dirty over clean technology. Related evidence from Thomas et al. (2022) shows that firms cut pollution abatement efforts to meet earnings targets. Gilje et al. (2020) show that financial distress causes firms in the oil and gas industry to pull forward drilling in existing oil wells at the expense of long-run project returns. Other research has shown that financial constraints and a high cost of capital cause firms to prefer investment in older capital (Eisfeldt and Rampini, 2007; Ma et al., 2022) which may be less environmentally friendly.

The large scale differences in levels of emissions across firms make this distinction important. A 100% reduction in emissions by a green firm is far less economically meaningful than a 1% reduction by a similarly-sized brown firm. The focus on percentage reductions is exacerbated by popular net-zero emissions targets (see Hong et al. (2023)), which entail a large percentage reduction in emissions and are easier to achieve for green firms with low initial levels of emissions. Perhaps most surprisingly, we find that sustainable investors reward green firms much more than brown firms for the same percentage reduction in emissions (logically, it should be the other way around). This additional mistake is consistent with an affect heuristic (e.g., Slovic et al., 2007), in which sustainable investors naively choose to disassociate from brown firms that they dislike.[8]

Before proceeding, it is important to recognize that sustainable investors can have different objectives (Starks, 2023). We show that the dominant sustainable investing strategy can be counterproductive relative to the commonly-stated investor goal of smoothly transitioning firms to become more green. A firm-level "transition" objective strives to save the environment while minimizing the loss in economic output.[9] It thereby emphasizes reducing emissions intensity, i.e., emissions per unit of output. However, a subset of sustainable investors pursue a more radical objective of lowering economy-wide emissions irrespective of maintaining output levels. These investors are sometimes characterized as pursuing "degrowth"—the deliberate shrinking or elimination of brown industries, or at its extreme, the shrinking of total global output.[10] The dominant sustainable investing strategy is not counterproductive relative to a degrowth objective. Indeed it is theoretically obvious that a sufficiently large increase in the cost of capital would deter entry and drive existing brown firms out of business, thus eliminating their emissions.

In theory, it is possible to avoid the large welfare loss associated with degrowth by pursuing an alternative *economy-wide* transition goal that shrinks brown firms but also grows green firms to replace the loss in output. Such a strategy is complicated by the fact that brown firms operate in industries such as agriculture and building materials, which produce outputs that are essential to society and

[8]Related evidence from Hartzmark and Sussman (2019), Heeb et al. (2022), Bauer et al. (2021), and Baker et al. (2022) suggest that sustainable investors are motivated by affect and social signaling, and exhibit willingness-to-pay that is not strongly related to the magnitude of impact.

[9]Or perhaps even increasing output. As summarized by a recent New York Times article, "If there is a dominant paradigm for how politicians and economists today think about solving climate change, it is called green growth—whose adherents populate European governments, the Organization for Economic Cooperation and Development, the World Bank and the White House—the global economy can both continue growing and defuse the threat of a warming planet through rapid, market-led environmental action and technological innovation. " https://www.nytimes.com/2021/09/16/opinion/degrowth-cllimate-change.html

[10]The New York Times article continues, "In the view of degrowthers, humanity simply does not have the capacity to phase out fossil fuels and meet the ever-growing demand of rich economies. At this late hour, consumption itself has to be curtailed. Degrowth is still a relatively marginal tendency in climate politics."

currently lack practical green alternatives. In the absence of green substitutes for entire brown industries, sustainable investors could contribute to the greening of a brown industry by investing in the firms *within* that industry that are relatively more green or that are meaningfully transitioning toward lower emissions. Importantly, this would not lead to underweighting brown industries as a whole or underweighting the greenest subset of firms within brown industries.

We show that, in practice, sustainable investors generally overweight green industries and underweight brown industries. Even the greenest firms within brown industries are underweighted relative to their market capitalization. To see why this could hinder an economy-wide transition goal, consider the high-emissions agriculture industry. If sustainable investors starve it of capital, less food will be produced. Growth of green industries such as insurance and legal services would not offset this loss because the products are not substitutable. Under the dominant strategy, there would be less emissions, but also less food.[11]

Finally, we acknowledge that the dominant sustainable investing strategy could have long-term consequences beyond what we capture in our analysis of emissions. For example, sustainable investors may aim to incentivize green R&D that will be implemented in the future by other firms. Providing long-term incentives for green R&D could be an effective investment strategy, but it does not describe the bulk of sustainable investing in practice.[12] According to Cohen et al. (2020), brown energy firms tend to be excluded from sustainable portfolios, despite the fact that these firms produce the most highly cited green patents.

Our paper contributes to the broader theory literature characterizing firm investment choices in the presence of various sustainable investing strategies (e.g., Heinkel et al. (2001), Pástor et al. (2021), Broccardo et al. (2020), Berk and van Binsbergen (2021), Edmans et al. (2022), Davies and Van Wesep (2018), and Oehmke and Opp (2022)). Existing models focus on the incentive for firms to become more green to access cheaper capital or a higher share price. We show empirically that this incentive channel, while theoretically promising, has been very weak for brown firms in practice. We instead focus on another important, yet understudied, channel: the *direct effect* of changes in the cost of capital

[11] This argument may seem at odds with existing academic theories where the shrinking of brown firms and growth of green firms leads to better environmental outcomes with minimal loss in total economic output (e.g., Heinkel et al. (2001); Broccardo et al. (2020); Pástor et al. (2021)). Existing theories generally do not model differentiated product markets; the output of green and brown firms are assumed to be perfectly substitutable. If one interprets these models as operating *within* an industry with substitutable products (e.g., within the agricultural industry), then the intuition of the models holds.

[12] For instance, Blackrock and Vanguard designate financial investment aimed at promoting green innovation as "impact" strategies (see also Barber et al. (2021) for a discussion of targeted impact funds). Although promising and growing in popularity, these strategies are marketed as risky and specialized investment products distinct from their mainstream sustainable investing products. Targeted "impact" funds constitute only 0.04% of Blackrock's $50 billion and 1.2% of Vanguard's $18 billion in assets in sustainable strategies.

on the environmental impact of firms. Due to large differences in this impact elasticity across brown and green firms, we show that the dominant sustainable investing strategy can be actively counterproductive instead of merely ineffective as argued by some of the existing research.

Our evidence that brown firms have a negative impact elasticity is consistent with earlier evidence in Hong et al. (2012) and Xu and Kim (2022) showing that firms do more social and environmental good when they are doing well and financially unconstrained. We differ in focus by showing that the magnitude of the relationship between firm environmental impact and financial constraints strongly varies by whether the firm is initially brown or green, which has important implications for the effectiveness of the dominant sustainable investing strategy.

Our findings are also related to the empirical literature highlighting problems in the current system of evaluating firm ESG and sustainability (e.g., Duchin et al. (2022), Gibson Brandon et al. (2021), and Berg et al. (2022)). Our analysis shows that ESG ratings are also flawed because they evaluate changes in emissions in percentage units, thus favoring green firms with little scope for real improvement. Heath et al. (2021) show that socially responsible investment funds buy firms with green characteristics, but these characteristics do not meaningfully improve after they are purchased. Our paper offers a complementary explanation for this—green firms have little scope to improve, even when incentivized to do so. Our findings suggest that sustainable investing flows and engagement that targets the incentives of green firms would be more effective if targeted at brown firms.[13]

Finally, while our focus is on sustainable investors who seek to improve the environmental impact of firms, our findings have implications for investors (including sophisticated institutional investors with purely pecuniary motives) who demand compensation for climate transition risk (e.g., Ilhan et al. (2023), Jung et al. (2023), Bolton and Kacperczyk (2021), and Alekseev et al. (2022)). If investors demand higher expected returns for brown firms because they believe brown firms face higher transition risk, brown firms will be subject to a higher cost of capital. Given their negative impact elasticity, the pricing of transition risk could ironically have the direct effect of making brown firms more brown.

[13] While engagement is not as common in the real world, there are some notable examples such as Engine No. 1, which has successfully engaged with Exxon Mobil to change its environmental impact (see also Krueger et al. (2020) and Akey and Appel (2019)). Other alternatives to the dominant sustainable investing strategy include regulation and carbon pricing (e.g., Pedersen (2023), Martinsson et al. (2023)).

II. Framework: Impact Elasticity

We define impact elasticity as the firm's change in environmental impact in response to a change in its cost of capital:

$$\text{impact elasticity} \equiv \frac{\partial \text{ environmental impact}}{\partial \text{ cost of capital}}.$$

Our primary contribution is to document heterogeneity in the impact elasticity as a function of the firm's initial level of green. We measure firm impact as the firm's greenhouse gas emissions per unit of output. Greater emissions implies a more negative firm environmental impact. Therefore, an increase in emissions following a positive shock to a firm's cost of capital translates to a negative impact elasticity.

To obtain sufficient statistical power, we examine a broad class of shocks to firms' cost of capital without restricting our attention to changes in financing costs that are due to sustainable investing. The underlying assumption is that, if the dominant sustainable investing strategy succeeds in altering firm's financing costs, firms would react in a similar fashion as they react to other changes in their financing costs.

Four important considerations apply to our measure of the impact elasticity. First, changes in the cost of capital due to sustainable investing may differ from other shocks to the cost of capital because sustainable investing could incentivize firms to become more green. In other words, firms could be motivated to become green by the inverse of the impact elasticity: the future change in a firm's cost of capital in response to a change in the firm's environmental impact. For example, a brown firm may choose to pursue green investment projects because it anticipates that sustainable investors will reward its positive change in impact by lowering its cost of capital in the future. While this incentive channel is promising in theory, we will present empirical evidence that the dominant sustainable investing strategy provided very weak financial incentives for brown firms in practice. Instead, sustainable investors and ESG ratings primarily reward firms that are already green for economically trivial but large percentage reductions in their emissions.

Second, we follow standard practice and measure firm environmental impact as a firm's emissions intensity, equal to raw emissions scaled by output. This scaled measure facilitates comparisons across firms of different sizes and matches the sustainable investing practitioner's literature, which often refers to the explicit goal of reducing firm emissions intensity. Such a "transition" goal implicitly recognizes a trade-off between emissions and production. We note that it is theoretically obvious that a sufficiently large increase in the cost of capital will cause any targeted firm or industry to shrink and eventually die, leading to eventual elimination of its emissions.[14] However, for investors who care about both emissions and production, we show that the dominant impact investing strategy can be counterproductive in that it makes brown firms much more brown per unit of production without making green firms meaningfully more green per unit of production.

Third, we measure the impact elasticity as the level change in a firm's emissions intensity for a unit change in its cost of capital. This differs from the standard convention in economics of measuring elasticities in terms of percentage changes or the change in the logarithm of the variable of interest. We focus on level changes on purpose, because brown and green firms start with vastly different levels of emissions. As we will show in the next section, a 100% reduction in emissions by a green firm has much less real environment impact than a 1% reduction in emissions by a similarly-sized brown firm.

Fourth, impact elasticity is a measure of firm-level changes in impact in response to firm-level changes in the cost of capital. In theory, sustainable investors could attempt to change the cost of capital at the project level instead of the firm level. This could be implemented through project-specific financing, such as subsidized financing for projects that benefit the environment. It could also be implemented by demanding a firm-level return that is a weighted average of the returns that investors demand for the firm's green and brown projects, where the weights are the sizes of the various projects. While project-specific financing has been shown to be effective in certain types of green debt (see e.g., Green and Vallee (2022)), the dominant sustainable investing strategy operates at the firm level, through divestment and underweighting of high-polluting firms, raising the cost of capital for all projects (including green ones) conducted by these brown firms. As we will show in the discussion of Table 11, the extent to which sustainable investors underweight brown firms is insensitive to the brown firm's recent reductions in emissions, consistent with non-project-specific financing for brown firms.[15] Thus, the dominant sustainable investing strategy of investing in green firms and divesting away from brown firms is an example of a firm-level shock to the cost of capital, and its effect would depend on the firm-level impact elasticity.

We also note that standard corporate finance theory implies that firms should assess potential

[14]Because it is theoretically obvious that a large increase in the cost of capital will reduce or eliminate output, and consequently emissions, we do not focus on the elasticity of raw emissions (unscaled by output) to the cost of capital. Thus, as we will discuss in Section IV.D, the dominant sustainable investing strategy is not counterproductive relative to a "degrowth" objective which seeks to lower emissions irrespective of maintaining output levels.

[15]This can be viewed as sustainable investors investing in a manner that violates the law of one price, because they apply a higher cost of capital to all projects pursued by brown firms, even when those projects are green. Empirical evidence of the violation of the law of one price can be seen in Duchin et al. (2022), which shows that brown firms achieve higher total valuation by separating brown and green assets into different firms.

investment projects using a project-specific cost of capital that reflects project-specific risk rather than a firm-wide cost of capital. Our firm-level impact elasticity measure can accommodate a project-specific valuation method from the firm's perspective. As shown in the next subsection, we assume that firm-level changes to the cost of capital due to the dominant sustainable investing strategy shifts the firm's project-specific discount rates equally across all projects.

A. Impact elasticities of brown and green firms

While the primary contribution of this paper is to provide empirical evidence, we present a simple stylized model to illustrate one, non-exclusive, reason why brown and green firms might differ in their impact elasticities. Consider a firm evaluating various investment opportunities. Each investment project can be approximated as a perpetuity that generates free cash flow C next year, growing at a rate g. The present value of the investment opportunity is:

$$PV = \frac{C}{r-g}.$$

It is straightforward to show that the value of the investment opportunity decreases in the cost of capital r, and the rate of decrease is greater for higher growth rates g:

$$\frac{\partial PV}{\partial r} < 0 \quad \text{and} \quad \frac{\partial^2 PV}{\partial r \partial g} < 0.$$

The underlying intuition is that an increase in the cost of capital is equivalent to an increase in the discount rate. A higher discount rate implies that cash in the present becomes more attractive relative to cash in the future. An increase in the discount rate makes all investment projects less attractive, but more so for investments with back-loaded cash flows, i.e., projects with higher growth rates.

Suppose that brown firms can choose between two investment opportunities: B or G, with the brown project leading to higher emissions than the green project. B could represent continuing or expanding existing brown production, cutting corners on meeting environmental regulatory standards, or reducing pollution abatement activities. G could represent investing in new pollution abatement technologies, doing more to meet or exceed environmental regulations, investing in new energy efficient and environmentally friendly equipment, or growing the portion of the business that is relatively more green. Because G involves the adoption of new capital, it has a relatively higher upfront cost and relatively more backloaded cash flows compared to B.[16]

Thus, we assume $C^B > C^G$ and $g^B < g^G$. We allow the projects to differ in risk, corresponding to project-specific costs of capital r^B and r^G. Suppose that, in the absence of sustainable investing, projects B and G have the same present value, so the firm is indifferent between them:

$$\frac{C^B}{r^B - g^B} = \frac{C^G}{r^G - g^G}.$$

Suppose that there is an increase $\delta > 0$ in the cost of capital for all investments by the brown firm, so the project-specific costs of capital for the brown and green projects are now $r^B + \delta$ and $r^G + \delta$, respectively. The fact that $\frac{\partial^2 PV}{\partial r \partial g} < 0$ implies that the brown project will now be strictly preferred:

$$\frac{C^B}{r^B + \delta - g^B} > \frac{C^G}{r^G + \delta - g^G}.$$

In other words, an increase in the cost of capital will make brown projects appear more attractive relative to green projects, leading to a negative impact elasticity.

In contrast, green firms operate in lines of business where they cannot generate large environmental externalities regardless of which investments are chosen. In our data, green firms are most likely to be in the industries of insurance, healthcare, and financial services. While a change in the cost of capital may lead green firms to prefer investment projects with more or less backloaded cash flows, the project's environmental impact is always negligible, leading to impact elasticities close to zero.

In the simple framework described in this section, we illustrate one *non-exclusive* reason why brown and green firms might differ in their impact elasticities. The framework above shows that the presence of financial constraints is not necessary to generate a negative impact elasticity for brown firms—an increase in the cost of capital directly leads the firm to prefer projects with more front-loaded cash flows. However, financial constraints could be an important channel that amplifies the negative impact elasticities of brown firms. A basic result from corporate finance theory is that financially constrained firms suffer from the debt overhang problem, in which they underinvest in positive NPV

[16] A brown firm can choose a brown project with negative or zero upfront costs by reducing pollution abatement activities or continuing existing brown projection, respectively. In contrast, transitioning to green production requires new investment that can be associated with long payback periods. For examples of how a brown firm can invest to reduce emissions intensity, see https://www.scientificamerican.com/article/solving-cements-massive-carbon-problem/. For estimates of abatement costs, see https://www.mckinsey.com/capabilities/operations/our-insights/net-zero-or-bust-beating-the-abatement-cost-curve-for-growth. For estimates of cash flows from carbon capture investment, see https://www.clifi.com/research-store/carbon-capture-and-storage-ccs-are-we-there-yetanalyzing-the-target-level-of-eua-prices-to-incentivize-ccs-adoption-in-europe.

projects that require upfront investment. To the extent that raising the cost of capital for brown firms increases their financial constraints, debt overhang would cause brown firms to underinvest in green projects because green projects tend to require up-front investment in new equipment.[17] For detailed models along these lines, see Lanteri and Rampini (2023), which shows that financially constrained firms choose to adopt dirtier technology than unconstrained firms, as well as Bolton et al. (2019), which shows that financial constraints can lead firms to prefer projects with front-loaded cash flows. Ma et al. (2022) provides direct empirical evidence that young firms buy old equipment because they are financially constrained.

III. Data

Our data sample covers the years 2002 to 2020. Data on greenhouse gas (GHG) emissions comes from S&P Global Trucost. GHG emissions are gas emissions that trap heat in the atmosphere and contribute to the risk of global climate change. The primary greenhouse gases emitted in the U.S. in 2020 are carbon dioxide (79%), methane (11%), nitrous oxide (7%), and fluorinated gases (3%) such as hydrofluorocarbons and perfluorocarbons.[18] We use data on scope 1 and 2 emissions. Scope 1 emissions are direct emissions from equipment that the firm owns. Scope 2 emissions are the indirect emissions associated with the purchase of electricity, steam, and heating, so they occur at a location not controlled by the firm, but are directly tied to firm actions. We present our main results for total scope 1 and scope 2 emissions and present our results separately for each type of emissions in the Appendix. We do not study scope 3 emissions (all other indirect emissions that occur in the firm's upstream and downstream activities), because reporting of scope 3 emissions is very noisy and involves double-counting (the scope 3 emissions of a customer firm could be the scope 1 emissions of a supplier firm), and because sustainable investing strategies primarily screen using scope 1 and 2 emissions.

Trucost coverage of firm emissions are based on firm self-reported disclosures combined with Trucost's proprietary model-based estimates of emissions. While there is likely noise in the model estimates, these are the same data commonly used by sustainable investors for portfolio construction and to measure progress in firm emissions behavior. In supplementary robustness results presented in the Appendix, we present qualitatively similar results using data from the subset of firms that directly self-report emissions data. We also supplement Trucost's firm-year-level data with industry-

[17] Financial constraints can lead to underinvestment in positive NPV green projects. If green projects instead have negative NPV under the current cost of capital, a reduction in the firm's cost of capital could shift the project's NPV into the positive range, leading to an increase in green investment. This would also correspond to a negative impact elasticity for brown firms.

[18] See https://www.epa.gov/ghgemissions/overview-greenhouse-gases.

year emissions intensity data generously shared by LaPlue and Erickson (2020), which are based on emissions data collected by the Environmental Protection Agency (EPA).

Accounting data on firm financial and real performance, leverage, earnings, and revenue are obtained from the Compustat database. Data relating to ESG ratings come from MSCI ESG Ratings (the data was previously known as the Riskmetrics KLD Ratings).

A natural reason for firms to vary in their emissions is differences in size. It is not obvious that a larger firm should be considered less green because it emits more greenhouse gases due to its larger scale, particular for an investor with a green transition goal. Therefore, we follow a convention commonly used by sustainable investment funds, ESG rating companies, and previous studies, and focus on emissions intensity, defined as scope 1 and scope 2 emissions scaled by revenue. Hereafter, we refer to emissions intensity as just "emissions" for brevity, unless otherwise noted. We divide firms into quintiles by their emissions in the previous year, with quintiles 1 and 5 representing brown and green firms, respectively. We classify firms in the middle three quintiles as neutral.

The analysis of the holdings of sustainable investment funds is based on data generously shared by the authors of Cohen et al. (2020). We categorize an investment fund as sustainable if it is defined as sustainable based on any of the measures described in the Cohen et al. (2020) paper. Specifically, we classify funds as sustainable if the fund name contains "ESG" or "green" or if the fund is classified as a sustainable investment fund by either the Forum for Sustainable and Responsible Investment (USSIF) or Charles Schwab. We merge data on sustainable funds with data on monthly holdings by mutual funds from CRSP. For each stock-month, we measure the extent to which it is overweighted by sustainable investment funds relative to the value-weighted market index. For example, if a stock represents 3% of the value of the combined portfolio of all sustainable funds and 2% of the value of the total market portfolio, then we would estimate that sustainable funds overweight the stock by 50%.

Data covering annual firm implied cost of capital (ICC) are generously shared by the authors of Lee et al. (2021). Following the best practices described in Lee et al. (2021), we use the mechanical ICC of Gebhardt et al. (2001) (GLS) as our preferred measure of the ICC. This measure is also similar to those used in previous papers in the ESG literature (e.g., Chava (2014)). As shown in Lee et al. (2021), the estimation of firm-level ICC can be noisy due to the necessity of making assumptions about expected future cash flows and nonunique numerical solutions. To mitigate the problems of noise, we show that our results are robust to using a simple average of four published ICC measures.

Table 1 presents summary statistics of the main variables used in our analysis. The distribution of the variables across the 10th, 50th, and 90th percentile indicate that emissions is extremely right skewed. Total raw emissions (unscaled) in the 90th percentile is equal to nearly 2000 times total raw emissions in the 10th percentile. After scaling by revenue to account for differences in firm size (our preferred measure of emissions), emissions in the 90th percentile are still 155 times as large as in the 10th percentile. The absolute value of annual level changes in emissions is similarly extremely right skewed, with the 90th percentile equal to 442 times the 10th percentile. In contrast, the absolute percentage change in annual emissions is far less skewed. However, as we will show, percentage changes in emissions are a poor measure of the true change in firm environmental impact because green firms with extremely low levels of emissions tend to be associated with large percentage changes in their emissions. These summary statistics offer an early indication of our main results: brown firms have the greatest environmental impact and the greatest scope to change their impact.

IV. Results

A. Levels and variability in firm emissions

We begin our analysis by showing that brown firms have much greater levels of and year-to-year variability in emissions compared to green firms. Variability is a useful measure because one reasonable estimate of how much a firm can change its environmental impact is how much it has changed in the past. Variability also provides an estimate of an upper bound for our ultimate measure of interest, the impact elasticity. Assuming that firms have experienced shocks to their cost of capital in the past, variability that is very close to zero implies that the impact elasticity must also be close to zero.

We divide firms into quintiles based on their level of emissions in each year, with quintile 5 representing firms with the lowest emissions. In subsequent analysis, we refer to firms in quintile 5 as "green," firms in quintile 1 as "brown," and firms in quintiles 2 through 4 as "neutral." In Figure 1 Panel A, which examines the raw level of green house gas emissions (unscaled), the average brown firm releases more than 1,700 times as much emissions as the average green firm. Of course, these differences in emissions across firms could be due to differences in firm size; it would be natural for larger firms to emit more GHG. Therefore, we use emissions scaled by same-year firm revenues as our baseline measure of emissions. In Panel B, we show that, even after scaling by revenues to form quintiles, brown firms release 261 times as much emissions per unit of revenue as green firms in quintile 5. Using both the raw and scaled measures of emissions, neutral firms in quintiles 2 through 4 are associated with emissions levels much closer to that of green firms than of brown firms.

The very large differences in emissions across the five quintiles shown in Figure 1 indicate that any analysis focusing on a firm's annual *percentage* change in emissions is unlikely to be informative. Consider a green firm. Even if it doubled or halved its emissions in a single year, its change in behavior would have minimal environmental impact because its baseline level of emissions is several orders of magnitude smaller than the emissions of brown firms of similar size. In contrast, if the average brown firm doubled its emissions, the real environmental impact would be equivalent to the average green firm increasing its emissions by 26,000%.

Thus, instead of focusing on percentage changes, we focus on the annual absolute level change in emissions (always scaled by revenue). In Table 2, we regress the annual absolute value of the change in emissions on indicators for the firm's emissions quintile, calculated in the previous year. Brown firms in quintile one represent the omitted reference category. The graphical analogue is presented in the top row of Figure 2.

We find a robust pattern in which brown firms exhibit substantially greater variability in their emissions. In the first column of Table 2, we include a fiscal year fixed effect to assess raw differences between green and brown firms after removing a general time effect. We find that the annual change in absolute emissions by brown firms exceeds that of green firms by approximately 180 tons per million dollars of sales. Graphically in the top left panel of Figure 2, this implies that the average annual variability of emissions by brown firms is 164 times the variability of emissions by green firms. Recall that green firms have an average level of emissions intensity of 5, which means the average *variability* in brown firms is about 35 times the average emissions *level* of green firms. Variability in emissions declines monotonically from quintile 1 to 5, but the largest gap lies between firms in quintile 1 (brown) and quintile 2. In other words, firms we classify as neutral are more similar to green firms than brown firms. In Column 2, we weight observations by firm market value as a fraction of market value in each year. We find similar patterns which shows that the large gap in variability of emissions between green and brown firms is not driven by small outlier firms.

In Column 3, we test whether the variability gap between brown and green firms holds within industry. We sort firms into quintiles according to their previous-year emissions rank within their SIC2 industry and control for SIC2 industry fixed effects. While much of the variation in emissions occurs across industries (and we will present results showing that sustainable investing strategies do not fully adjust for industry), we find a similar pattern in which brown firms within an industry year exhibit significantly greater variability in emissions than green firms.

In supplementary results shown in the Appendix, we examine annual absolute changes in emissions separately for scope 1 and scope 2 emissions. We find significant variability gaps between green and brown firms for both types of emissions. The gap for scope 1 emissions is much larger, consistent with the fact that the level of scope 1 emissions is much larger than the level scope 2 emissions. We also find similar patterns using the absolute level of total emissions, without scaling by firm sales.

In the bottom row of Figure 2, we show that differences in variability in emissions across brown and green firms disappear if we measure annual changes in emissions using percentage changes instead of level changes. Green firms have close to or greater percentage variability in their emissions compared to brown firms. We caution that a large percentage change in the emissions of green firms is not economically meaningful, because green firms are associated with levels of emissions several orders of magnitude smaller than the level of emissions for similarly-sized brown firms.

B. Impact elasticity

In this section, we estimate the impact elasticity of green and brown firms by examining how emissions by each type of firm changes following changes to the cost of capital. We begin by using firm and industry financial returns and financial distress measures as proxies for shocks to the cost of capital of firms. Then we present three empirical tests designed to isolate a financial channel, as distinct from shocks to firm productivity.

The dominant sustainable investing strategy seeks to lower the cost of capital for green firms by directing capital toward them and to increase the cost of capital for brown firms by divesting away from them. If green firms react to a lower cost of capital by reducing their emissions (i.e., green firms have a negative impact elasticity), and brown firms react to a higher cost of capital by reducing their emissions (i.e., brown firms have a positive impact elasticity), then we expect that the dominant sustainable investing strategy will cause both brown and green firms to improve their impact on the environment. However, as we will show, the actual impact elasticity of green firms is close to zero and the impact elasticity of brown firms is large and negative. Together, these measures imply that the dominant sustainable investing strategy may be counterproductive in that it causes brown firms to become more brown without causing green firms to become meaningfully more green.

B.1 Financial returns

We begin by examining the relation between changes in emissions over the next year and a firm's financial performance as measured by its equity returns in the previous year. A positive return in the previous year raises the firm's market valuation and is likely to ease the firm's access to financing, corresponding to a lower cost of capital. Likewise, a negative financial return in the previous year likely corresponds to an increase in the firm's cost of capital. In this and all subsequent analyses, we compare changes in emissions from brown, green, and neutral firms, where these classifications are based on emissions in the previous year. We also control for SIC industry fixed effects in this and future regressions to account for cross-industry variation in the general time trend of emissions over our sample period.

One limitation of simply looking at the relation between firm emissions and past returns is that any measured correlation could be driven by reverse causality (e.g., if anticipation of the firm becoming more green causes a change in its share price) or by omitted variables bias (e.g., if the arrival of an environmentally friendly CEO causes both a shift in green production and share price). To better estimate the causal effect of firm returns on firm emissions, we examine the relation between firm emissions and the firm's industry value-weighted return, calculated excluding the focal firm. The intuition is that the industry return should affect firm-level financial performance, but individual firm choices regarding emissions should not have a strong effect on the industry return calculated excluding the focal firm.

In Table 3, we find that brown firms are significantly more elastic to shocks to firm financial performance than green firms across a variety of specifications. Column 1 shows a large and highly significant negative coefficient on the firm annual return for brown firms indicating that as firm financial performance improves, brown firms reduce their emissions. Symmetrically, the negative coefficient implies that negative performance by brown firms is associated with an increase in emissions. In terms of magnitude, the coefficient of -56.92 implies that a 10% financial return for brown firms is associated with a reduction in emissions of more than 5 tons per million dollars of revenue. This *change* in emissions by brown firms due to a modest change in financial returns is equal to the average *level* of emissions for green firms. In contrast, neutral and green firms have close-to-zero and insignificant coefficients on the firm annual return. These results are consistent with brown firms having a large negative impact elasticity and green firms having a close-to-zero impact elasticity.

In Column 2, we find similar patterns using industry returns (calculated excluding the focal firm) instead of firm returns. These results using industry returns imply that our estimates are unlikely to be due to reverse causality or omitted variables. Rather, exogenous shocks to firm financial performance, as proxied by the industry return, are associated with large declines in emissions by brown firms and small insignificant changes in emissions by green firms. Note that the coefficients for brown firms estimated using industry returns are slightly larger than those using individual firm returns. This may occur because individual firm financial returns are a noisier measure of the true cost of capital change for a firm than the industry average return. This would lead to greater attenuation bias toward zero when using the firm return instead of the industry return.

In all specifications in Table 3, brown firms pollute less following positive financial shocks and pollute more following negative financial shocks. In contrast, green firms have smaller and inconsistently signed changes in emissions. We can confidently reject the hypothesis that brown and green firms have equal elasticities (p-values for a test of equality in coefficients are below 0.01).

If our results are driven by investment choices, it may take longer than a year for the influence of such investments to fully express itself in the data as changes in firm emissions. Thus, we expect to find similar or larger changes in emissions for brown firms at longer horizons.

Further, a potential concern with the interpretation of our results is that they may be driven by short-term stickiness in raw emissions (unscaled) when firms grow or shrink sales in response to shocks to the cost of capital. For example, suppose that an airline cuts its loyalty program and advertising investment in response to an increase in its cost of capital, leading to a reduced number of passengers. In the short run, the airline is contractually obligated to operate the same number of flights, so it will operate each flight with fewer passengers and hence have higher emissions intensity (measured as raw emissions scaled by sales). In the long run, however, the airline can reduce the number of routes and sell aircraft, leading to an increase in passenger per flight and a reduction in emissions intensity toward its original levels.

If our results over a one-year horizon are driven by short-term stickiness in raw emissions, our results would not represent the longer-term shift in emissions intensity by firms in response to the shock. If this were the case, we would not find a similar effect over longer periods that allowed for complete responses to the shock. Note that such a concern is relevant even if the cost of capital shock is permanent (as desired by many sustainable investors), because a firm may require time to adjust its production process to the permanent change in its cost of capital.

To explore whether our results are explained by this short-term channel, we examine changes in emissions over a five-year horizon. Table 4 shows regressions where the dependent variable is the change in emissions intensity in year $t + 5$ relative to year t, and the change to the cost of capital is represented by financial returns (measured continuously or with an indicator for returns in the lowest decile) in year $t-1$ at the firm or industry level (calculated excluding the focal firm). We find qualitatively similar results to our previous one-year analysis, with larger effect sizes. These longer-horizon results suggest that our findings of a large negative impact elasticity for brown firms are not driven by short-term stickiness or fixed adjustment costs for emissions. The fact that changes in emissions are larger when measured at a five-year horizon than a one-year horizon is consistent with the simple model presented in Section II: an increase (decrease) in the cost of capital causes brown firms to prefer brown (green) investment projects, and the effect of these investment choices on emissions could take several years to fully materialize.

In Appendix Table A3, we repeat the analysis of long-term reactions, with additional control variables for interim firm or industry financial returns in the years between t and $t+4$, interacted with indicators for firm type (brown, neutral, or green), because these interim returns could also impact firm outcomes. We find very similar estimates with these additional controls. This is unsurprising because both firm and industry returns exhibit weak serial correlation in our data.

B.2 Financial distress

A common refrain from sustainable investors is that they wish to punish firms that harm the environment by starving them of capital and pushing them toward financial distress. Before getting to the empirical results, we note that there are reasons ex ante to be skeptical that financial distress would encourage brown firms to become more green. An increase in the firm's cost of capital should cause the firm to prefer investment projects that deliver front-loaded cash flows over those with back-loaded cash flows. In particular, a firm that is in a liquidity crisis or has a high risk of bankruptcy faces a high discount rate, such that the firm will favor investments offering short-term gains. Since transitioning to greener production by brown firms usually entails the adoption of new equipment and technologies that differ from their existing brown investment projects, these new green investments are unlikely to pay off in the very short run and should be less attractive to firms in financial distress. Furthermore, firms near bankruptcy may suffer from the well-known debt overhang problem (Myers, 1977) in which they are unable to raise financing to pursue projects that require upfront investment.

In Table 5, we measure financial distress in four ways. First, we examine an indicator for whether the firm is likely to face challenges in making interest payments on its existing debt. The low interest coverage indicator is equal to one if firms have positive interest payments and negative earnings, or the firm has an earnings-to-interest ratio that is in the bottom decile within our sample. Second, we measure each firm's Altman Z-score (lower values correspond to greater probability of bankruptcy; see Altman (1983)), and set the low Z-score indicator equal to one if the firm has a Z-score in the bottom decile within our sample. Lastly, we use indicators for whether the firm's financial return is in the bottom decile within our sample. To establish a causal channel, we also examine firm reactions to industry shocks, using indicators for whether the industry return (calculated excluding the focal firm) is in the bottom decile of our sample.

Across all specifications in Table 5, we find that brown firms react to distress by increasing their emissions. In contrast, neutral and green firms exhibit smaller, inconsistently signed, and less significant responses to the proxies of distress. P-value tests of equality show that we can reject the null hypothesis that brown and green firms have equal changes in emissions after experiencing distress. The magnitudes of the coefficients imply that brown firms increase their emissions by approximately 25 to 50 tons per million of revenue after experiencing a distress shock associated with being in the lowest decile of some measure (interest coverage, Z-score, or financial returns) within our sample period. Given that the average level of emissions by green firms is only 5 tons per million in revenue, these results imply that brown firms react to distress by increasing their emissions by at least five times the level of emissions of the average green firm.

We find that brown firms pollute more per unit of output as they become financially distressed. Thus, pushing brown firms toward bankruptcy is counterproductive relative to the goal of transitioning brown firms toward being more green. As we discussed in the Introduction, some sustainable investors may pursue a different degrowth objective, where they seek to shrink or kill brown firms, thereby reducing or eliminating their absolute emissions. We discuss this objective in Section IV.D.

B.3 Isolating the financial channel

So far, we have explored the relation between a firm's environmental impact and various proxies for the firm's cost of capital, such as bankruptcy risk and financial returns. A potential concern with the empirical measures above is that they could capture shocks to productivity in addition to the cost of capital. In this section, we present three additional tests to isolate a financial channel operating through the cost of capital. First, we examine firms' implied cost of capital, a measure that captures the portion of past returns that is due to changes in the cost of capital, as distinct from changes in cash flow expectations. Second, to identify the role of financial constraints, we assess whether firms that are more leveraged react differently to industry productivity shocks. Third, we exploit exogenous variation in a firm's cost of capital induced by changes in investor demand for dividend payments.

In our first test to isolate a cost-of-capital effect, we directly measure the implied cost of capital (ICC) for each firm year. The ICC is defined as the internal rate of return that equates the firm's market value with the present value of expected future cash flows. Thus, the ICC represents the expected return to investors of the firm and the firm's cost of raising capital from the same investors. The change in ICC is designed to be a measure of the portion of past returns that is due to changes in the cost of capital, not changes in expected cash flows. Before proceeding, we stress that these tests are meant as a complement to our previous results. Estimates of ICC may be noisy due to non-unique numerical solutions and sensitivity of estimates to the timing of measurement and assumptions regarding the path of future cash flows (for more details, see Lee et al. (2021)).

We use estimates of firm ICCs generously shared by Lee et al. (2021). As our baseline, we follow the recommendations of Lee et al. (2021) and use ICCs estimated following the Gebhardt et al. (2001) (GLS) method where the inputs for future cash flows consist of mechanical forecasts from the cross-sectional forecast model of Hou et al. (2012). To ensure robustness, we also present results using a composite ICC that is the equal-weighted average for four ICC variants.

In Table 6, we regress the firm's change in emissions intensity on the firm's change in ICC over the previous year, interacted with indicators for whether the firm is brown, neutral, or green. We also control for the direct effects of the firm type indicators (brown, green, or neutral), fiscal year, and SIC2 industry fixed effects.

We find that brown firms significantly increase their emissions following an increase in their cost of capital. Once again, neutral and brown firms experience smaller and inconsistently signed changes in their emissions. This is true using the GLS as well as the composite ICC estimates. For example, the coefficient in Column 1 implies that brown firms increase emission by 6.3 tons per million following a one percentage point increase in their ICC. Because an increase in emissions translates to a negative change in environmental impact, these results again imply that brown firms have large negative impact elasticities with respect to their cost of capital, whereas neutral and green firms have smaller impact elasticities closer to zero.

Similarly to our earlier analysis of firm performance, a limitation of looking at the relation between firm emissions and firm ICC is that any measured correlation could be driven by reverse causality (if becoming more green causes the firm to have a lower cost of capital), or by omitted variables bias (e.g., if the arrival of an environmentally friendly CEO causes both a shift in green strategy and cost of capital). To better estimate the causal effect of firm cost of capital on firm emissions, we examine the relation between firm emissions and the firm's industry value-weighted average ICC, calculated excluding the focal firm. The intuition is that industry cost of capital shocks strongly affect firm-level cost of capital, but individual firm choices should not have a strong effect on the industry average cost of capital calculated excluding the focal firm. We find a similar large relation between brown firm emissions intensity with respect to industry ICC, and a smaller and insignificant relation for neutral and green firms. These patterns are robust to using the equal-weighted average for four ICC variants.

In our second test to isolate a cost-of-capital effect, we compare the behavior of firms with different initial amounts of leverage following the same industry productivity shock. Firms that are more leveraged are likely to be more sensitive to productivity shocks because a given level of negative performance increases their probability of bankruptcy and costly financial distress more than for a less constrained firm. Such constrained firms may face additional pressure to increase or maintain cash flows in the short term. For brown firms, this short-termism can translate into dirtier production and higher emissions.

We measure industry productivity shocks for each firm using the value-weighted change in industry return on assets (ROA), calculated excluding the focal firm. In Table 7, we regress the firm's change in emissions on the triple interaction of the change in industry ROA, the firm's leverage in the previous year, and indicators for firm type (brown, neutral, or green), controlling for all direct effects and two-way interactions. We find that the relationship between changes in emissions and changes in industry productivity in the previous year is significantly stronger for brown firms with low interest coverage or higher debt-to-value ratios. Levered green firms have smaller reactions in the opposite direction.[19] These results help identify the effect of financial distress as distinct from the general effects of negative performance. For the same negative industry performance shock, highly leveraged brown firms increase emissions more than less leveraged brown firms. This result is consistent with an increase in financial distress that causes brown firms to become more brown.

In our third test to isolate a cost-of-capital effect, we exploit exogenous variation in firm's cost of capital induced by changes in investor demand for dividend payments. Pure dividend demand is behavioral in nature, because rational investors understand that a dividend payment comes with a corresponding drop in value of the firms' equity and therefore does not make them wealthier or

[19] Green firms, especially leveraged ones, experience a smaller significant increase in emissions following positive productivity shocks. This increase in emissions could be driven in part by green services firms expanding beyond their headquarters or online operations to local physical offices or branches following improvements in productivity, leading to an increase in emissions.

poorer (Miller and Modigliani, 1961). Real-world frictions imply that receiving a dividend payout is generally suboptimal for taxable investors. Even so, Hartzmark and Solomon (2019) show that a large class of investors value dividends as distinct from the total return on their equity investments. This behavioral demand influences share prices along a variety of dimensions (e.g., Baker and Wurgler (2004) and Hartzmark and Solomon (2013)).

Importantly for the purposes of this paper, there is large and systematic time variation in the behavioral demand for dividend payments. For example, in low interest rate environments, investors substitute away from fixed income investments toward dividend-paying stocks based on the misguided perception of dividends as a safe income stream similar to interest collected on bonds. Hartzmark and Solomon (2019) show that in times of high demand for dividend payments, dividend-paying firms experience increased share prices relative to non-dividend-paying firms. Fluctuations in share price due to variation in demand for dividends represent cost of capital shocks driven by misguided investors rather than productivity shocks to affected firms.

In addition, Hartzmark and Solomon (2013) develop a new proxy for dividend payout demand, which has the advantage of being distinct from the general demand to hold the types of firms that pay dividends (e.g., investors may wish to invest in dividend-paying firms because these firms are perceived to be more stable). This proxy builds on the fact that dividend announcement days reveal all the relevant economic information of an upcoming dividend payment, and the ex-dividend date is the date when all tax ramifications are resolved. The interim period of approximately one month, after the dividend announcement and before the ex-dividend date, has no fundamental economic content and thus should contain no abnormal returns. Yet investors who do not already hold the stock prior to the dividend announcement and want to receive the announced dividend payment (whether due to their own biases or to cater to clients with such biases (e.g., Harris et al. (2015))) must buy the stock in this interim period. Hartzmark and Solomon (2013) document large positive returns in this interim period from price pressure induced by investor demand for dividend payouts. We use time series variation in this measure as a proxy for variation in shocks to the cost of capital of dividend paying firms driven by behavioral demand for dividend payouts.[20]

We measure dividend demand as the value-weighted interim return across all dividend payment events in each year. We measure dividend demand both continuously and with an indicator for

[20] While price pressure due to trading in the interim period partly reverses subsequent to dividend payment, Hartzmark and Solomon (2019) document that variation in this proxy captures broader variation in demand for dividend paying stocks due to demand for dividend payouts. For our purposes of identifying a cost of capital shock, this aspect is the most relevant.

whether dividend demand was above the median during our sample period.[21] Note that we do not claim that dividend demand is uncorrelated with macroeconomic variables that could affect firm emissions. For example, dividend demand is higher during low-interest rate environments, when many investors substitute from bonds toward dividend-paying stocks. Rather, our identifying assumption is that fundamentals such as interest rates that drive dividend demand should have a similar effect on all brown firms, but brown firms that ex ante offer a high dividend yield will experience an additional reduction in their cost of capital thanks to dividend demand.

In Table 8, we examine how emissions from firms with high dividend yields change with demand for dividend payouts. Specifically, we regress changes in firm emissions on aggregate dividend demand in the prior year, an indicator for whether the firm had a high dividend yield (above the median of dividend payers) in the prior year, and interactions with our green/brown/neutral firm-type indicators. In Column 1, the coefficient for brown firms on the interaction between the high dividend yield firm indicator and dividend demand is large and highly statistically significant. In Column 2, the coefficient for brown firms on the interaction between the high dividend yield firm indicator and the high dividend demand indicator is -58 and again highly statistically significant. These estimates imply that in the years when dividend demand was high, brown high-dividend-yield firms decreased their emissions by an extra 58 tons per million of revenue compared to brown non-high-dividend-yield firms.[22] In comparison, the estimated changes in emissions for green high-dividend-yield firms are small and insignificantly different from zero. Altogether, these regression results show that increases in the cost of capital induced by variation in dividend demand cause high-dividend-yield brown firms to increase emissions. We do not see similar effects for other brown firms or for high-dividend-yield green firms.

B.4 Robustness

In this section, we show that our main findings are robust to alternative measures of greenhouse gas emissions.

In our baseline results, we used data on annual scope 1 and scope 2 emissions from S&P Trucost, the sustainable investing industry's leading provider of emissions-related data. Trucost's coverage

[21]See Hartzmark and Solomon (2013, 2019) for further information and time series variation in the measure.

[22]Hartzmark and Solomon (2019) show that dividend-paying firms experience a 0.1 decline in their book-to-market ratios during high dividend demand periods, translating to slightly greater than 10% improvement in financial returns. Table 8 implies that the 10% improvement in returns due to dividend demand leads to an approximate 6 ton per million reduction in emissions by high dividend-yield brown firms. This magnitude approximately matches our earlier findings in Table 3.

of firm emissions is based on firms' self-reported disclosures combined with Trucost's proprietary model-based estimates of firms' annual emissions. Although there is likely to be measurement error in these model estimates, these are the same data commonly used by sustainable investors as a screening tool for portfolio choice and as a way to measure progress in firm emissions behavior. In supplementary results presented in Appendix B, we present qualitatively similar results using data from the subset of firms that directly self-report annual emissions data. While the reduced sample size leads to slightly noisier estimates, we find qualitatively similar and generally statistically significant effects, consistent with brown firms having a negative impact elasticity and green firms having a close-to-zero impact elasticity.

We also supplement Trucost's firm-year-level data with industry-year emissions intensity data. The industry emissions data is generously shared by LaPlue and Erickson (2020) and are based on emissions data collected by the Environmental Protection Agency (EPA) from plant-level reporting. While statistical power declines due to the smaller sample size, these data have the benefit of capturing the total change in industry emissions, *including the effects of entry and exit of firms*. In Appendix Table A4, we find that past industry financial returns are associated with a reduction in industry emissions for brown industries and a close-to-zero change in emissions for green industries. These results are again consistent with our conclusion that brown firms have a negative impact elasticity and green firms have a close-to-zero impact elasticity.

C. Incentive effects of the dominant sustainable investing strategy

So far, we have shown that brown firms have large negative impact elasticities and green firms have impact elasticities that are close to zero. Together, these elasticities imply that if the dominant sustainable investing strategy succeeds in altering firms' cost of capital, it would have the *direct effect* of making brown firms more brown, without making green firms more green. In this section, we explore the possibility that the dominant sustainable investing strategy could have an additional indirect incentive effect on firm behavior. Specifically, if it is known that sustainable investors reward firms that improve their impact, then brown firms may be incentivized to become more green to access a lower cost of capital or higher share price in the future.

In theory, providing financial incentives can be an effective way to motivate brown firms to become more green. However, we show empirically that the dominant sustainable investing strategy in practice has not yet provided such incentives.

To study these indirect incentive effects, we examine the extent to which the dominant sustainable investing strategy over the past two decades has rewarded green and brown companies that have improved their environmental impact. Using data on the holdings of sustainable investment funds, we test whether sustainable investors increase their holdings of firms that have lowered their emissions, holding the current level of emissions constant. Using data on ESG ratings released by MSCI, a leading sustainable investment advisory firm, we also test whether firms are rewarded for a decrease in emissions with improvements in their environmental ESG ratings.

Our analysis yields results that imply no meaningful financial incentives for brown firms to become more green. We find that sustainable investment funds indeed overweight firms that have improved their impact over the past several years, consistent with these funds rewarding firms who transition to becoming more green. However, changes in impact are measured in the wrong units. Sustainable investors appear to suffer from a proportional thinking bias (see, e.g., Tversky and Kahneman (1981) and Shue and Townsend (2021)) in which they reward firms with large *percentage* reductions in emissions rather than large *level* reductions in emissions.[23]

Popular ESG environmental ratings similarly reward percentage reductions in emissions rather than level reductions in emissions. For example, the Financial Times recognized firms as climate leaders based on a ranking of percentage reductions in emissions intensity (see Figure 3). Unsurprisingly, the top 10 climate leaders all started with emissions intensity levels below 35 tons per million dollars of revenue. In contrast, the brown firms in our sample have emission intensity levels that average 1,308 tons per million. It is much more costly for a brown firm with high levels of pollution to have a similar high percentage reduction in emissions.

Using data generously shared by Cohen et al. (2020), we classify funds as sustainable if the fund name contains "ESG" or "green" or if the fund is classified as a sustainable investment fund by either the Forum for Sustainable and Responsible Investment (USSIF) or Charles Schwab. To assess whether a firm is favored by sustainable funds, we compare the holdings of two portfolios: the aggregated holdings of all sustainable funds within a year and the holdings of a hypothetical market portfolio that holds all firms in CRSP in proportion to their market value as of the beginning of the year. We measure the extent to which a firm is rewarded by sustainable funds using its "overweight," defined as the difference between the stock's portfolio weight in the aggregate sustainable fund portfolio and

[23]The "miles per gallon illusion" describes a related bias in which people undervalue the benefits of replacing the most inefficient automobiles relative to replacing already fuel efficient automobiles with even more fuel efficient ones Larrick and Soll (2008).

the market portfolio, scaled by its weight in the market portfolio.

In Table 9, we regress the firm's overweight in the aggregate sustainable fund portfolio on the firm's current level of emissions as well as the firm's change in emission in the past one or two years. In Columns (1) and (2), we measure the firm's change in emissions in levels. We argue that this is the correct measure of the change in real-world environmental impact of firms. Note that because we measure emissions as emissions scaled by revenue, measuring the change in emissions in levels is already adjusted for differences in firm size. In Columns (3) and (4), we measure the firm's change in emissions as the percentage change. This is the incorrect measure of the change in real firm environmental impact. As shown earlier in the bottom row of Figure 2, green firms are associated with large absolute percentage changes. These large percentage changes in emissions by sustainable funds are economically trivial because their level of emissions is several orders of magnitude smaller than the level of emissions of similarly-sized brown firms.

The estimates in Table 9 show that the current level of emissions and percentage changes in emissions are both strong predictors of sustainable fund holdings. Green investment funds reward firms with lower current levels of emissions as well as larger percentage reductions in their emissions. However, the estimated coefficients on the level changes in emissions in Columns (1) and (2) are close to zero and statistically insignificant. In other words, green investment funds, as a whole, fail to reward firms for reducing emissions in the units that actually matter for real environmental impact.

In Table 10, we find very similar results using the firm's ESG environmental rating as the dependent variable. We find that ESG ratings reward firms with lower current levels of emissions as well as larger percentage reductions in their emissions. However, the estimated coefficients on the level changes in emissions in Columns (1) and (2) are again close to zero and statistically insignificant.

The distinction between percentage and level changes in emissions is important because, holding constant firm size, the average brown firm emits 260 times as much pollution as the average green firm. Comparing a brown and green firm of equal size, an increase in emissions by a brown firm of 1% has the same actual environmental impact as an increase in emissions by a green firm of 260%.

Perhaps most surprisingly, we find that sustainable investors reward green firms more than brown firms for the same percentage reduction in emissions. To incentivize brown firms to improve, sustainable investors should do the opposite and reward brown firms more for the same percentage reduction in emissions. In Table 11, we show that sustainable investors significantly increase their portfolio weights in neutral and green firms in response to percentage reductions in their emissions. However, sustainable investors do not increase their portfolio weights for brown firms that exhibit the same percentage reduction in their emissions. The behavior of sustainable investors stands in contrast to the behavior of the MSCI environmental ratings (see Columns 3 and 4). While environmental ratings reflect changes in emissions measured in the wrong units (percentage instead of level changes in emissions), environmental ratings at least reward percentage reductions in emissions in a similar fashion across brown, neutral, and green firms.

The fact that the aggregate sustainable investing portfolio does not reward reductions in emissions by brown firms is consistent with a behavioral affect heuristic (e.g., Slovic et al., 2007), in which sustainable investors choose to disassociate from or punish brown firms that they dislike, despite the fact that brown firms have the greatest scope to change their environmental impact. The insensitivity of sustainable portfolio weights to improvements in environmental impact by brown firms is also consistent with the widespread use of exclusion lists such as the Carbon Underground 200,[24] which encourages investors to divest from brown firms based on ownership of potentially polluting assets.

D. Product substitutability and degrowth

Our analysis has shown that an increase in the cost of capital for brown firms has the direct effect of making them pollute more per unit of output. This outcome is counterproductive to the objective of a smooth "transition," which aims to lower the emissions intensity of brown firms. However, as outlined in the Introduction, a large increase in the cost of capital would inevitably deter entry and drive existing brown firms out of business, thereby eliminating their emissions. Whether these effects are counterproductive relative to alternative *economy-wide* sustainability goals depends on the scope of these goals and the strategy implemented.

One relatively radical sustainability goal is "degrowth" of the entire economy, which seeks to reduce emissions without regard to losses in total output and aggregate human consumption. A significant increase in the cost of capital for brown firms aligns with this extreme degrowth objective since it could lead to the elimination of brown firms and their emissions.[25]

In theory, it is possible to avoid the large welfare loss associated with degrowth by pursuing an alternative *economy-wide* transition goal that shrinks brown firms but also grows green firms to replace

[24] See https://fossilfreefunds.org/carbon-underground-200.

[25] While there are proponents of a economy-wide degrowth strategy, degrowth adherents are typically viewed as misguided ideologues. Popular culture frequently depicts degrowth advocates as villains who prioritize the planet over humanity. Recent examples include Thanos in the Avengers, Poison Ivy in Batman, Eteon in Fast & Furious Presents: Hobbs & Shaw, King Orm in Aquaman, Valentine in The Kingsman, the butterflies in Peacemaker, and the ETO in the Three Body Problem trilogy, among many others.

the loss in output. The welfare cost of a decrease in output from brown firms disfavored by sustainable investors depends on the extent to which that loss in output can be substituted with growth in output from green firms favored by sustainable investors. As previously discussed, green industries like insurance, healthcare, finance, and legal services provide imperfect substitutes for essential products from brown industries like energy, agriculture, transportation, and building materials. In addition to being costly, the lack of substitutes for essential brown products means that demand for such products may be fairly inelastic and difficult to meaningfully shrink if alternative goods are not provided. In the absence of green substitutes for entire brown industries, sustainable investors could contribute to a green transition at an industry level by investing in the firms *within* a brown industry that are relatively more green or are transitioning toward becoming more green. Thus, whether the dominant sustainable investing strategy is aligned with an economy-wide green transition goal depends on how sustainable investors adjust their portfolios based on the substitutability of the brown output they are attempting to shrink.

This section explores the allocation patterns of sustainable investors within and across industries. To avoid loss of output from an entire industry, sustainable investment should occur based on sorting *within* an industry. For example, given people cannot survive without food, a reasonable sustainable investing goal would be to replace brown agricultural output with green agricultural output. To this end, sustainable investors should overweight firms within agriculture that have relatively low emissions or are transitioning toward lower emissions. Importantly, this would not lead to an underweighting of the agriculture industry as a whole or an underweighting of the greenest subset of firms within agriculture.

However, our data reveals a different pattern. Sustainable investors on average overweight entire green industries while underweighting brown ones. Continuing with the agriculture example, the aggregate sustainable portfolio drastically underweights agriculture relative to a value-weighted market portfolio. Agricultural production of livestock in 2020 is weighted at 7% of its market value and agricultural production of crops is weighted at 25% of its market value. Further, there is no reason to expect that the green industries that are overweighted would be able to fill in for this loss in agricultural output while maintaining lower emissions intensity. For example, in the unlikely event that the insurance industry (which is held by sustainable funds at 232% relative to its market cap) attempted to grow crops, it is doubtful it would be able to grow crops with lower emissions intensity than existing agricultural firms.

Consistent with this example, Panel A of Figure 4 presents a binscatter plot of the relation between SIC2 industry emissions and the industry's overweight in the aggregate sustainable portfolio. Industries with high emissions are significantly underweighted by sustainable investment funds and industries with low emissions tend to be overweighted. Among industries with very low emissions, there exists dispersion in how these industries are weighted in the aggregate sustainable portfolio. This dispersion likely reflects the reality that sustainable investors care about factors beyond emissions, such as the social and governance components of ESG. Nevertheless, the figure shows a clear negative slope in which the aggregate sustainable fund underweights industries with high emissions.

Our results showing that sustainable funds underweight brown SIC2 industries may seem at odds with marketing claims that some sustainable funds are sector-adjusted (so that portfolio weights for each sector match the market capitalization of each sector). This apparent contradiction can be explained by the fact that many sustainable funds adjust their portfolio weights using very broad sector definitions, and products produced by firms within a sector are unlikely to be fully substitutable. For example, the influential MSCI sustainable indexes are adjusted using 11 GICS sectors. The GICS sector of consumer staples contains both the agriculture and drug retail industries, which clearly produce imperfect substitutes as products.

In Panel B of Figure 4, we again plot industry emissions against sustainable portfolio weights, this time focusing only on the 20% of firms in each industry-year with the lowest emissions intensity. The results mirror those of Panel A, indicating that sustainable funds heavily underweight even the greenest firms within brown industries. The main difference relative to Panel A is a cluster of binscatter points with very high portfolio weights and low emissions, reflecting the tendency of sustainable investors to substantially overweight the greenest firms within green industries. However, our earlier analysis shows that rewarding the greenest of the green is unlikely to lead to improvements in their environmental impact, as these firms have the least room for further improvement.

We acknowledge that the SIC2 industry classification used in our analysis represents a noisy measure of true output substitutability; output produced by different firms within an SIC2 industry may not be perfectly substitutable, and output across pairs of SIC2 industries will vary in their substitutability. Ideally, sustainable investors would use an industry classification that better captures product substitutability from a welfare perspective. Nevertheless, even with our noisy industry categories, we expect the greenest firms within brown industries to be overweighted if investors construct their portfolios to grow the types of firms that can realistically substitute for shrinking brown output. We do not find evidence of such a strategy in practice.

Finally, we note that our analysis in this section is not meant as a critique of all sustainable investing strategies. Indeed, some sustainable investors do "industry-adjust," by investing in relatively green firms and firms that have meaningfully reduced their emissions within a brown industry without underweighting the brown industry as a whole. Such a strategy could potentially be effective in helping critical industries smoothly transition toward lower emissions intensity. However, our results show that, on average, sustainable investing funds underweight and overweight entire brown and green industries, respectively. They also heavily underweight relatively green firms within brown industries. Thus, the dominant investing strategy, in its current form, may result in costly degrowth instead of a smooth transition at the economy-wide level.

V. Conclusion

This paper shows that the dominant sustainable investing strategy of directing capital toward green firms and away from brown firms can be counterproductive. We develop a new measure of impact elasticity, defined as a firm's change in environmental impact due to a change in its cost of capital. We show empirically that a reduction in financing costs for firms that are already green leads to small improvements in environmental impact at best. Increasing financing costs for brown firms leads to negative changes in firm impact. We further show that the dominant sustainable investing strategy provides very weak financial incentives for brown firms to become less brown. Due to a mistaken focus on *percentage* reductions in emissions, the sustainable investing movement primarily rewards green firms for economically trivial reductions in their already low levels of emissions. Finally, we show that the dominant sustainable investing strategy has not allocated capital toward relatively green firms within brown industries. Instead, it overweights green services industries that are unlikely candidates to produce output that can easily substitute for shrinking brown output.

Our conclusions are not meant as a negative assessment of all possible sustainable investment strategies. Rather, they highlight potential problems with some of the most popular sustainable investment strategies to date. These strategies go by a variety of names, such as divestment, exclusion, negative screening, and certain forms of ESG integration. Collectively, they lead to an underweighting of brown firms and overweighting of green firms, while offering weak incentives for brown firms to improve. Our analysis suggests that sustainable investment flows and engagement that targets the incentives of green firms would be more effective if targeted at the incentives of brown firms.

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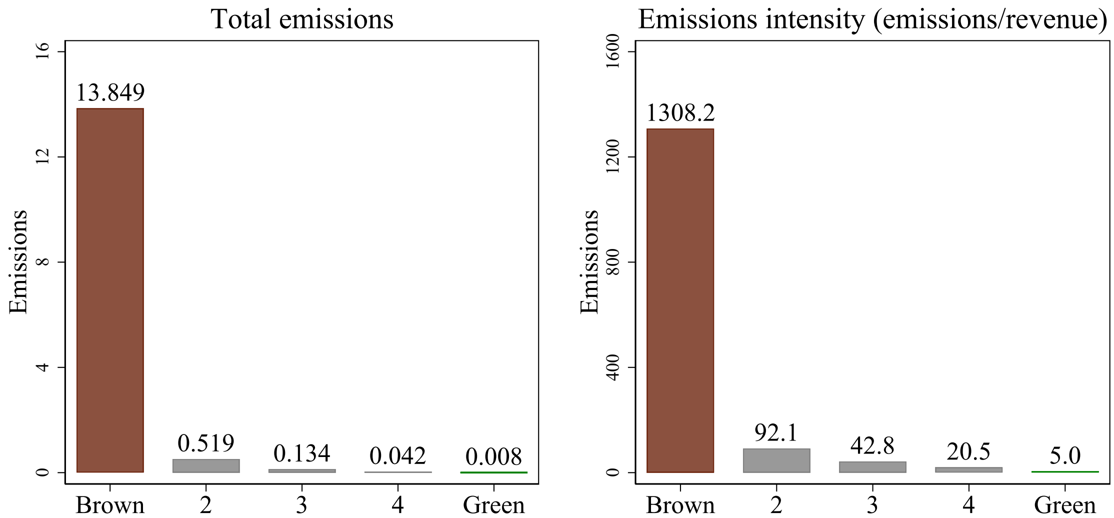
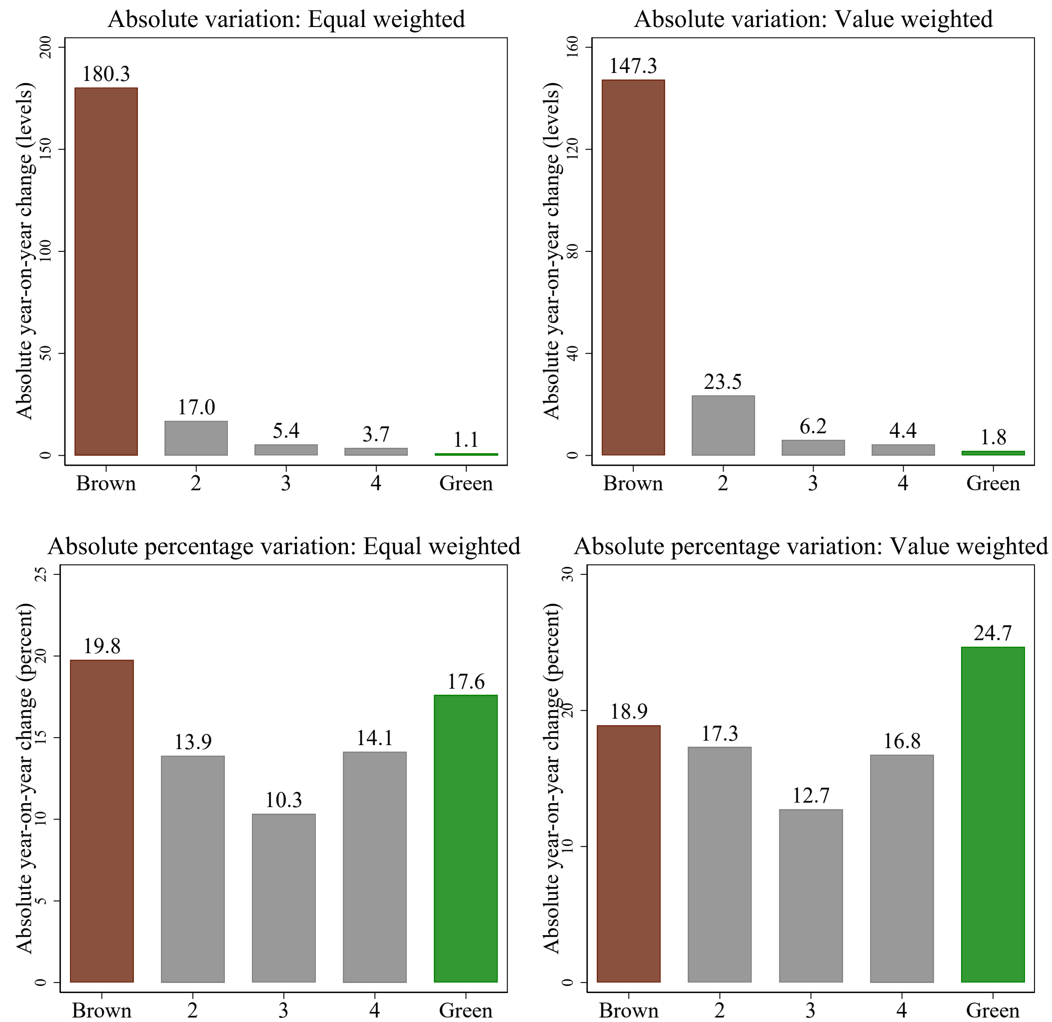
Figure 1: Average emissions of brown and green firms



This figure plots the average emissions of scope 1 and scope 2 greenhouse gases by firms. Firms are sorted into quintiles within each year, with quintile 1 representing brown firms with the highest emissions and quintile 5 representing green firms with the lowest emissions. In the left panel, emissions are measured as million tons of CO_2 equivalents. In the right panel, emissions are measured as tons of CO_2 equivalents emitted per million dollars of revenue (emission intensity).

Figure 2: Absolute variation and percentage changes in emissions



This figure plots year-on-year variation in emissions. Variation in emissions for the top two panels is measured as the absolute change in scope 1 and scope 2 emissions intensity from year t to $t+1$, where emissions intensity is measured in tons of CO_2 equivalents emitted per million dollars of revenue. Variation in emissions for the bottom two panels is measured as the absolute percentage change in scope 1 and scope 2 emissions intensity from year t to $t+1$. Absolute changes and absolute percentage changes in emissions are winsorized at the 1% level. In all panels, quintiles are computed within each fiscal year. Observations in panels on the left are equal weighted, while those in panels on the right are weighted by the firm's market capitalization as a fraction of total CRSP market size in the same year.

Figure 3: Focus on percentage reductions in emissions intensity

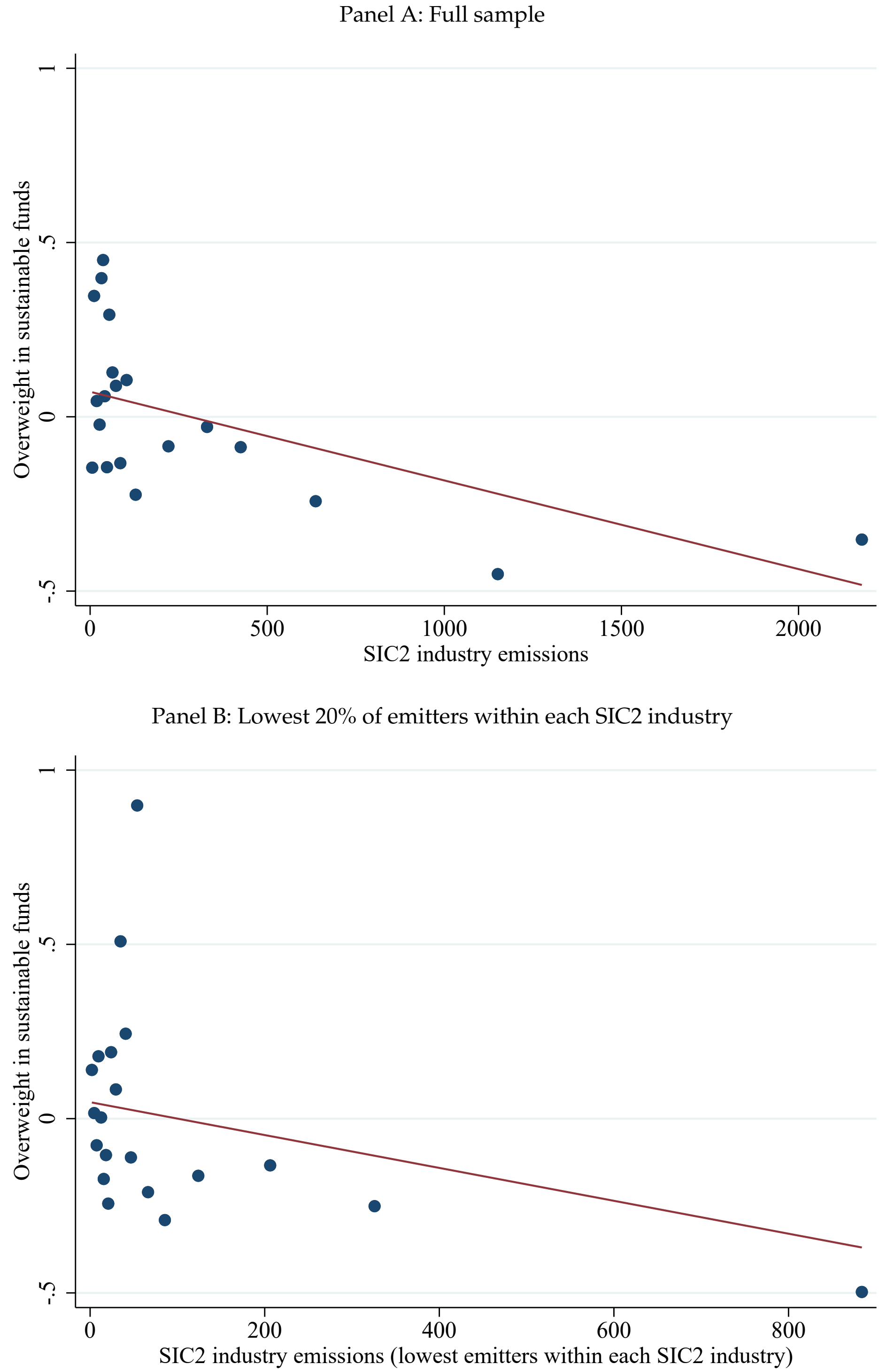
FT FINANCIAL TIMES | CLIMATE LEADERS 2022
statista

Europe's Climate Leaders 2022

Company	Country	Sector	Reduction of core emissions intensity (Scope 1 and 2) YoY 2015-20 [1]	Core emissions intensity (GHGs in tonnes per €mn revenue) [2]	Core emissions in tonnes (CO2 equivalent) [2]	Total reduction of core emissions 2015-20 [3]	Scope 3 emissions reported? [4]	CDP rating [5]	Participation in Science Based Targets initiative (SBTi) [6]
Logitech International	Switzerland	Technology & Electronics	46.8%	0.4	1,889	88.9%	yes	-	Committed
CAP	Italy	Energy & Utilities	45.2%	14.2	3,365	95.1%	yes	-	-
ICA Gruppen	Sweden	Retail & Ecommerce	42.4%	1.5	19,394	92.1%	yes	Not scored (F)	Targets set, well below 2°C
Rosenberger	Germany	Technology & Electronics	42.3%	0.4	554	89.6%	no	-	-
Vaisala	Finland	Technology & Electronics	41.3%	1.1	431	91.7%	yes	B	-
SEGRO	UK	Property	39.5%	7.2	3,489	86.0%	yes	B	Targets set, 1.5°C
Sopra Steria	France	Consulting & Professional Services	39.4%	1.1	4,842	72.9%	yes	A	Targets set, 1.5°C
Garrigues	Spain	Consulting & Professional Services	37.2%	0.9	329	88.8%	yes	-	-
Akzo Nobel	Netherlands	Chemicals & Materials	36.5%	26.4	225,360	94.1%	yes	Not scored (F)	Targets set, 1.5°C
Intermediate Capital Group	UK	Financial Services	36.4%	0.2	195	80.8%	yes	B	Targets set, 1.5°C

This figure reproduces the Financial Times ranking of the top climate leaders of 2022. Firms are ranked according to their percentage reductions in emissions intensity. The top ten climate leaders all started with emissions intensity levels below 27 tons per million dollars of revenue. This can be contrasted with brown firms in our sample, which have emissions intensity levels averaging 1,308 tons per million.

Figure 4: Sustainable fund allocations by SIC2 industry



This figure shows the relation between each SIC2 industry's emissions and the extent to which the industry is overweighted in the aggregate sustainable fund portfolio. Panel A uses data on industry emissions in each year based on a value-weighted average of all firms within each SIC2 industry. Panel B uses data computed only using the 20% of firms within each year with the lowest emissions within each SIC2 industry. Observations underlying the estimates are at the industry-year level, with the industry overweight demeaned by year. Estimates are derived from a regression of the industry's overweight in the aggregate sustainable fund portfolio (relative to the weight implied by the industry's market capitalization) on the industry's emissions (measured as emissions / output). Dots represent a binscatter plot with 20 bins, each representing 5% of the sample.

Table 1: Summary statistics

	Mean	SD	p10	p50	p90
Total emissions	2.9063	14.2767	0.0019	0.0938	3.7277
Emissions intensity (emissions/revenue)	257.9102	733.6114	3.4575	40.6942	534.5153
Absolute changes in emissions	41.5508	138.0794	0.1899	2.2738	83.8643
Absolute percentage changes in emissions	0.1960	1.0431	0.0130	0.0634	0.3352
Changes in emissions	-5.3007	108.4962	-25.1790	-0.4828	12.9887
Annual return	0.1507	0.4765	-0.3494	0.0990	0.6377
Industry annual return	0.1908	0.2369	-0.0705	0.1831	0.4241
ΔICC	-0.0006	0.0265	-0.0274	-0.0013	0.0285
ΔIndustry ICC	-0.0010	0.0125	-0.0135	-0.0017	0.0141
ΔICC composite	0.0035	0.0607	-0.0545	-0.0001	0.0700
ΔIndustry ICC composite	-0.0002	0.0300	-0.0306	-0.0033	0.0341

This table presents summary statistics for our main analysis sample, consisting of observations at the firm-year level. Total emissions is measured as million tons of CO_2 equivalents. Emissions intensity is tons of emissions per million dollars of revenue. Hereafter, we refer to emissions intensity as emissions for brevity. Absolute change in emissions is the absolute value of the annual change in the level of emissions. Absolute percentage change in emissions is the absolute value of the annual fractional change in emissions. Annual return is the annual return of the firm. Industry annual return is the annual value-weighted return within each SIC2 industry, calculated excluding the focal firm. ΔICC is the annual change in the firm implied cost of capital estimated using the mechanical GLS method, as described in Lee et al. (2021). ΔIndustry ICC is the annual value-weighted change in industry ICC, calculated excluding the focal firm. ΔICC composite is the annual change in the firm implied cost of capital estimated using the composite method, as described in Lee et al. (2021). ΔIndustry ICC composite is the annual value-weighted change in industry ICC composite, calculated excluding the focal firm.

Table 2: Absolute change in emissions intensity by quintile

	Absolute changes in emissions		
	(1)	(2)	(3)
Quintile 2	-163.3***	-124.1***	-55.39***
	(8.448)	(13.11)	(5.934)
Quintile 3	-175.1***	-140.8***	-72.06***
	(8.409)	(12.01)	(5.988)
Quintile 4	-176.6***	-142.8***	-86.44***
	(8.393)	(12.04)	(6.258)
Quintile 5	-179.2***	-146.0***	-92.64***
	(8.390)	(12.09)	(6.401)
Year FE	Yes	Yes	No
SIC2 industry FE	No	No	Yes
Value-weighted	No	Yes	No
Within SIC2 industry	No	No	Yes
N	24345	24330	24280
R^2	0.262	0.259	0.372

This table shows year-on-year variation in emissions by quintiles representing the level of emissions. The dependent variable is the absolute change in scope 1 and scope 2 greenhouse gas emissions from year t to $t+1$, where emissions is measured in tons of CO_2 equivalents emitted per million dollars of revenue. We regress the dependent variable on quintile dummies of emissions intensity in year t. Estimated coefficients represent the difference in absolute year-on-year variation in emissions relative to the omitted category, quintile 1 representing brown firms. Standard errors are clustered at the firm-level. In columns (1) and (2), quintiles are computed within each fiscal year, while in column (3), quintiles are computed within each fiscal year$\times$SIC2 industry. Columns (1) and (2) include year fixed effects, and column (3) includes year and SIC2 industry fixed effects. In column (2) regressions are value-weighted where each observation is weighted by the firm's market capitalization as a fraction of total CRSP market size in the same year. *, **, and *** indicate significance at the 10%, 5%, and 1% levels, respectively. Standard errors are in parentheses and are clustered at the firm-level.

Table 3: Emissions and financial performance

	Changes in emissions	
	(1)	(2)
Brown × Annual return	-56.92***	
	(8.760)	
Neutral × Annual return	2.437**	
	(1.082)	
Green × Annual return	1.904	
	(1.261)	
Brown × Industry annual return		-94.93***
		(17.32)
Neutral × Industry annual return		-1.133
		(4.838)
Green × Industry annual return		-0.769
		(5.565)
p-value: Brown × X = Green × X	0.000	0.000
Type FE	Yes	Yes
Year FE	Yes	Yes
SIC2 industry FE	Yes	Yes
N	23921	24271
R^2	0.0497	0.0471

This table shows changes in firms' emissions following changes in firm or industry financial performance. The dependent variable is the change in scope 1 and scope 2 greenhouse gas emissions from year t to $t+1$, where emissions is measured in tons of CO_2 equivalents emitted per million dollars of revenue. We regress the dependent variable on the interactions between firm- or industry-level returns in the previous year and indicators for whether the firm is brown, neutral, or green. All other variables are as defined in Table 1. All columns include year fixed effects, SIC2 industry fixed effects, and indicators for whether the firm is brown, neutral, or green. Below each regression, we report the p-value for the test of whether the coefficient for the interaction term containing the indicator for brown firms is equal to the coefficient for the interaction term containing the indicator for green firms. *, **, and *** indicate significance at the 10%, 5%, and 1% levels, respectively. Standard errors are in parentheses and are clustered at the firm-level.

Table 4: Long run changes in emissions and financial performance

	Changes in emissions			
	(1)	(2)	(3)	(4)
Brown × Annual return	-135.9***			
	(33.73)			
Neutral × Annual return	2.267			
	(5.688)			
Green × Annual return	-1.450			
	(3.497)			
Brown × Industry annual return		-242.5***		
		(63.14)		
Neutral × Industry annual return		-36.24***		
		(13.93)		
Green × Industry annual return		-21.87		
		(15.29)		
Brown × Low annual return			178.7***	
			(41.33)	
Neutral × Low annual return			5.095	
			(7.548)	
Green × Low annual return			6.693	
			(6.795)	
Brown × Low industry annual return				117.2***
				(32.85)
Neutral × Low industry annual return				29.74**
				(13.01)
Green × Low industry annual return				18.45
				(12.00)
p-value: Brown × X = Green × X	0.000	0.000	0.000	0.000
Type FE	Yes	Yes	Yes	Yes
Year FE	Yes	Yes	Yes	Yes
SIC2 industry FE	Yes	Yes	Yes	Yes
N	12308	12412	12308	12412
R^2	0.128	0.127	0.126	0.124

This table shows long run changes in firms' emissions following changes in firm or industry financial performance. The dependent variable is the 5-year change in scope 1 and scope 2 greenhouse gas emissions from year t to $t+5$, where emissions is measured in tons of CO_2 equivalents emitted per million dollars of revenue. We regress the dependent variable on the interactions between measures of firm or industry returns in the previous year and indicators for whether the firm is brown (quintile 1 in terms of emissions in year t), neutral (quintiles 2-4), or green (quintile 5). Low annual return (low industry annual return) indicator is equal to one if the firm has an annual return (industry annual return) in the bottom decile within our sample. All other variables are as defined in Table 1. All columns include year fixed effects, indicators for whether the firm is brown, neutral, or green, and SIC2 industry fixed effects. Below each regression, we report the p-value for the test of whether the coefficient for the interaction term containing the indicator for brown firms is equal to the coefficient for the interaction term containing the indicator for green firms. *, **, and *** indicate significance at the 10%, 5%, and 1% levels, respectively. Standard errors are in parentheses and are clustered at the firm-level.

Table 5: Emissions and financial distress

	Changes in emissions			
	(1)	(2)	(3)	(4)
Brown × Low interest coverage	26.15*			
	(14.80)			
Neutral × Low interest coverage	-6.135***			
	(1.189)			
Green × Low interest coverage	-4.218***			
	(1.289)			
Brown × Low Z-score		34.90***		
		(12.96)		
Neutral × Low Z-score		-5.333***		
		(1.273)		
Green × Low Z-score		0.508		
		(2.117)		
Brown × Low annual return			56.33***	
			(10.64)	
Neutral × Low annual return			-6.053***	
			(1.408)	
Green × Low annual return			-5.636***	
			(2.057)	
Brown × Low industry annual return				42.92***
				(10.99)
Neutral × Low industry annual return				-2.107
				(3.396)
Green × Low industry annual return				-1.581
				(3.308)
p-value: Brown × X = Green × X	0.041	0.009	0.000	0.000
Type FE	Yes	Yes	Yes	Yes
Year FE	Yes	Yes	Yes	Yes
SIC2 industry FE	Yes	Yes	Yes	Yes
N	19747	19069	23921	24271
R^2	0.0404	0.0425	0.0440	0.0423

This table shows changes in firms' emissions following financial distress. The dependent variable is the change in scope 1 and scope 2 greenhouse gas emissions from year t to $t+1$, where emissions is measured in tons of CO_2 equivalents emitted per million dollars of revenue. We regress the dependent variable on the interactions between indicators for financial distress in the previous year and indicators for whether the firm is brown (quintile 1 in terms of emissions in year t), neutral (quintiles 2-4), or green (quintile 5). The low interest coverage indicator is equal to one if the firm has positive interest payments and negative earnings, or the firm has an earnings to interest ratio that is in the bottom decile within our sample. The low Z-score indicator is equal to one if the firm has an Altman Z-score in the bottom decile within our sample. Low annual return (low industry annual return) indicator is equal to one if the firm has an annual return (industry annual return) in the bottom decile within our sample. All columns include year fixed effects, indicators for whether the firm is brown, neutral, or green, and SIC2 industry fixed effects. Below each regression, we report the p-value for the test of whether the coefficient for the interaction term containing the indicator for brown firms is equal to the coefficient for the interaction term containing the indicator for green firms. *, **, and *** indicate significance at the 10%, 5%, and 1% levels, respectively. Standard errors are in parentheses and are clustered at the firm-level.

Table 6: Emissions and implied cost of capital (ICC)

	Changes in emissions			
	(1)	(2)	(3)	(4)
Brown × ΔICC	630.0***			
	(154.5)			
Neutral × ΔICC	-34.18			
	(21.49)			
Green × ΔICC	-3.030			
	(19.71)			
Brown × ΔIndustry ICC		555.4*		
		(291.7)		
Neutral × ΔIndustry ICC		-219.6***		
		(82.22)		
Green × ΔIndustry ICC		-93.11		
		(72.39)		
Brown × ΔICC composite			378.9***	
			(110.5)	
Neutral × ΔICC composite			-14.43	
			(15.20)	
Green × ΔICC composite			-12.20	
			(16.12)	
Brown × ΔIndustry ICC composite				518.0***
				(136.9)
Neutral × ΔIndustry ICC composite				-26.43
				(28.91)
Green × ΔIndustry ICC composite				29.22
				(31.74)
p-value: Brown × X = Green × X	0.000	0.026	0.001	0.000
Type FE	Yes	Yes	Yes	Yes
Year FE	Yes	Yes	Yes	Yes
SIC2 industry FE	Yes	Yes	Yes	Yes
N	16249	24160	7054	22732
R^2	0.0506	0.0396	0.0588	0.0418

This table shows changes in firms' emissions following changes in firm or industry implied cost of capital (ICC). Measures of the ICC are as defined in Table 1. The dependent variable is the change in scope 1 and scope 2 greenhouse gas emissions intensity from year t to $t+1$, where emissions intensity is measured in tons of CO_2 equivalents emitted per million dollars of revenue. All columns include year fixed effects, SIC2 industry fixed effects, and indicators for whether the firm is brown, neutral, or green. Below each regression, we report the p-value for the test of whether the coefficient for the interaction term containing the indicator for brown firms is equal to the coefficient for the interaction term containing the indicator for green firms. *, **, and *** indicate significance at the 10%, 5%, and 1% levels, respectively. Standard errors are in parentheses and are clustered at the firm-level.

Table 7: Interaction between leverage and real productivity shocks

	Changes in emissions	
	(1)	(2)
Brown × Low interest coverage × ΔIndustry ROA	-563.8*	
	(305.7)	
Neutral × Low interest coverage × ΔIndustry ROA	-17.89	
	(46.53)	
Green × Low interest coverage × ΔIndustry ROA	184.4**	
	(87.26)	
Brown × Firm leverage × ΔIndustry ROA		-922.5*
		(504.3)
Neutral × Firm leverage × ΔIndustry ROA		16.26
		(101.9)
Green × Firm leverage × ΔIndustry ROA		335.9***
		(110.5)
p-value: Brown × X × Z = Green × X × Z	0.019	0.014
Type × ΔIndustry ROA	Yes	Yes
Type × Low interest rate	Yes	No
Type × Firm Leverage	No	Yes
Type FE	Yes	Yes
Year FE	Yes	Yes
SIC2 industry FE	Yes	Yes
N	19677	24169
R^2	0.0415	0.0419

This table shows the interaction between leverage and real productivity shocks. The dependent variable is the change in scope 1 and scope 2 greenhouse gas emissions from year t to $t+1$, where emissions is measured in tons of CO_2 equivalents emitted per million dollars of revenue. We regress the dependent variable on the interactions between firm leverage (as measured by an indicator for low interest coverage or the firm's debt-to-market value ratio), the change in industry ROA, and indicators for whether the firm is brown (quintile 1 in terms of emissions in year t), neutral (quintiles 2-4), or green (quintile 5). The low interest coverage indicator is equal to one if the firm has positive interest payments and negative earnings, or the firm has an earnings to interest ratio that is in the bottom decile within our sample. All other variables are as defined in Table 1. All columns include year fixed effects, indicators for whether the firm is brown, neutral, or green, the interactions between firm type and firm leverage (or indicator for low interest coverage), the interactions between firm type and the change in industry ROA, and SIC2 industry fixed effects. Below each regression, we report the p-value for the test of whether the coefficient for the interaction term containing the indicator for brown firms is equal to the coefficient for the interaction term containing the indicator for green firms. *, **, and *** indicate significance at the 10%, 5%, and 1% levels, respectively. Standard errors are in parentheses and are clustered at the firm-level.

Table 8: Dividend demand shocks to the cost of capital

	Changes in emissions	
	(1)	(2)
Brown × High dividend yield firm × Dividend demand	-87.45***	
	(32.01)	
Neutral × High dividend yield firm × Dividend demand	1.687	
	(3.361)	
Green × High dividend yield firm × Dividend demand	-2.621	
	(2.305)	
Brown × High dividend yield firm × High dividend demand		-56.44***
		(17.31)
Neutral × High dividend yield firm × High dividend demand		-0.623
		(1.859)
Green × High dividend yield firm × High dividend demand		-0.559
		(1.038)
p-value: Brown × X × Z = Green × X × Z	0.008	0.001
Type × Dividend demand	Yes	No
Type × High dividend demand	No	Yes
Type FE	Yes	Yes
Year FE	Yes	Yes
SIC2 industry FE	Yes	Yes
N	16742	16742
R^2	0.0551	0.0553

This table shows the relationship between emissions and dividend demand shocks. The dependent variable is the change in scope 1 and scope 2 greenhouse gas emissions from year t to $t+1$, where emissions is measured in tons of CO_2 equivalents emitted per million dollars of revenue. Dividend demand is an annual variable equal to the value-weighted interim return (in %) between the dividend announcement day and the ex-dividend day across all dividend payment events in the previous year. The high dividend demand indicator represents whether the interim return was above the median over our sample period. High dividend yield firm is an indicator for whether the firm had a dividend yield above the median of dividend payers in the prior year. All columns control for the direct effects and interactions of (High) dividend demand, indicators for whether the firm is brown, neutral, or green, year fixed effects, and SIC2 industry fixed effects. Below each regression, we report the p-value for the test of whether the coefficient for the interaction term containing the indicator for brown firms is equal to the coefficient for the interaction term containing the indicator for green firms. *, **, and *** indicate significance at the 10%, 5%, and 1% levels, respectively. Standard errors are in parentheses and are clustered at the firm-level.

Table 9: Portfolio holdings of sustainable funds and changes in emissions

	Overweight in aggregated sustainable funds			
	(1)	(2)	(3)	(4)
Emissions	-0.00726***	-0.00808***	-0.00697***	-0.00764***
	(0.00237)	(0.00253)	(0.00233)	(0.00248)
$\Delta_{t,t-1}$ Emissions (changes in levels)	-0.00196			
	(0.00554)			
$\Delta_{t,t-2}$ Emissions (changes in levels)		0.000651		
		(0.00455)		
$\Delta_{t,t-1}$ Emissions (changes in percents)			-0.106***	
			(0.0385)	
$\Delta_{t,t-2}$ Emissions (changes in percents)				-0.0584**
				(0.0279)
Year FE	Yes	Yes	Yes	Yes
N	24345	21118	24345	21118
R^2	0.0106	0.0113	0.0108	0.0114

This table shows how the relation between the holdings of sustainable funds and firm emissions. The dependent variable measures the extent to which a firm is overweighted in the aggregate sustainable portfolio relative to the stock's weight in a value-weighted market portfolio (overweight is calculated as $\frac{w_{SF}-w_{mkt}}{w_{mkt}}$, where w_{SF} is the stock's weight in the aggregate sustainable portfolio and w_{mkt} is the stock's weight in a value-weighted market portfolio). All columns control for the level of emissions. Columns (1) and (2) control for the one- and two-year change in the level of emissions, respectively. Columns (3) and (4) control for the one- and two-year percentage change in emissions, respectively. All columns include year fixed effects. *, **, and *** indicate significance at the 10%, 5%, and 1% levels, respectively. Standard errors are in parentheses and are clustered at the firm-level.

Table 10: Environmental ESG ratings and changes in emissions

	Environmental score			
	(1)	(2)	(3)	(4)
Emissions	-0.0190***	-0.0197***	-0.0188***	-0.0196***
	(0.00346)	(0.00361)	(0.00348)	(0.00364)
$\Delta_{t,t-1}$Emissions (changes in levels)	-0.00514			
	(0.00748)			
$\Delta_{t,t-2}$Emissions (changes in levels)		0.00172		
		(0.00756)		
$\Delta_{t,t-1}$Emissions (changes in percents)			-0.130***	
			(0.0347)	
$\Delta_{t,t-2}$Emissions (changes in percents)				-0.0874***
				(0.0256)
Year FE	Yes	Yes	Yes	Yes
N	9887	8568	9887	8568
R^2	0.155	0.167	0.156	0.169

This table shows the relation between ESG environmental ratings and changes in emissions as measured in terms of level or percentage changes. The dependent variable is the MSCI ESG environmental score. All columns control for the level of emissions. Columns (1) and (2) control for the one- and two-year changes in the level of emissions, respectively. Columns (3) and (4) control for the one- and two-year percentage changes in emissions, respectively. All columns include year fixed effects. *, **, and *** indicate significance at the 10%, 5%, and 1% levels, respectively. Standard errors are in parentheses and are clustered at the firm-level.

Table 11: Portfolio holdings of sustainable funds and changes in emissions by firm type

	Overweight in aggregated sustainable funds		Environmental score	
	(1)	(2)	(3)	(4)
Emissions	-0.00633**	-0.00608**	-0.0161***	-0.0155***
	(0.00308)	(0.00303)	(0.00444)	(0.00464)
Brown × $\Delta_{t,t-1}$Emissions (change in percents)	-0.0142		-0.133*	
	(0.0734)		(0.0698)	
Neutral × $\Delta_{t,t-1}$Emissions (change in percents)	-0.161***		-0.121**	
	(0.0553)		(0.0538)	
Green × $\Delta_{t,t-1}$Emissions (change in percents)	-0.199***		-0.146**	
	(0.0574)		(0.0589)	
Brown × $\Delta_{t,t-2}$Emissions (change in percents)		0.00814		-0.0836
		(0.0473)		(0.0526)
Neutral × $\Delta_{t,t-2}$Emissions (change in percents)		-0.0908**		-0.0673*
		(0.0385)		(0.0364)
Green × $\Delta_{t,t-2}$Emissions (change in percents)		-0.169**		-0.147***
		(0.0704)		(0.0489)
p-value: Brown × X = Green × X	0.050	0.042	0.890	0.370
Year FE	Yes	Yes	Yes	Yes
Type FE	Yes	Yes	Yes	Yes
N	24345	21118	9887	8568
R^2	0.0110	0.0119	0.159	0.173

This table shows how sustainable investing reacts to percentage changes in firm emissions depending on whether the firm is brown, neutral, or green. The dependent variable in columns (1) and (2) is the stock's overweight in the aggregate sustainable portfolio as defined in Table 9. The dependent variable in columns (3) and (4) is the stock's MSCI KLD environmental rating as defined in Table 11. All columns include year fixed effects and indicators for whether the firm is brown, neutral, or green. Below each regression, we report the p-value for the test of whether the coefficient for the interaction term containing the indicator for brown firms is equal to the coefficient for the interaction term containing the indicator for green firms. *, **, and *** indicate significance at the 10%, 5%, and 1% levels, respectively. Standard errors are in parentheses and are clustered at the firm-level.

Online Appendix for

Counterproductive Sustainable Investing

Samuel M. Hartzmark   Kelly Shue

Appendix A

Table A1: Absolute change in emissions scope 1 intensity by quintile

	Absolute changes in emissions		
	(1)	(2)	(3)
Quintile 2	-148.8***	-113.9***	-45.30***
	(7.901)	(11.62)	(5.589)
Quintile 3	-156.9***	-126.1***	-61.62***
	(7.880)	(10.84)	(5.633)
Quintile 4	-158.1***	-126.6***	-72.22***
	(7.858)	(10.75)	(5.802)
Quintile 5	-159.1***	-127.9***	-79.87***
	(7.870)	(10.78)	(6.044)
Year FE	Yes	Yes	No
Year $\times$ SIC2 FE	No	No	Yes
Value-weighted	No	Yes	No
Within SIC2 industry	No	No	Yes
N	24345	24330	24280
R^2	0.259	0.253	0.385

This table shows year-on-year variation in emissions by quintiles representing the level of emissions. The dependent variable is $|e_{t+1} - e_t|$, the absolute change in scope 1 greenhouse gas emissions, where emissions is measured in tons of CO_2 equivalents emitted per million dollars of revenue. We regress the dependent variable on quintile dummies of emissions intensity in year t. Estimated coefficients represent the difference in absolute year-on-year variation in emissions relative to the omitted category, quintile 1 representing brown firms. Standard errors are clustered at the firm-level. In columns (1) and (2), quintiles are computed within each fiscal year, while in column (3), quintiles are computed within each fiscal year$\times$SIC2 industry. Columns (1) and (2) include year fixed effects, and column (3) includes year and SIC2 industry fixed effects. In column (2), each observation is weighted by the firm's market capitalization as a fraction of total CRSP market size in the same year. *, **, and *** indicate significance at the 10%, 5%, and 1% levels, respectively. Standard errors are in parentheses and are clustered at the firm-level.

Table A2: Absolute change in emissions scope 2 intensity by quintile

	Absolute changes in emissions		
	(1)	(2)	(3)
Quintile 2	-17.13***	-23.23***	-11.89***
	(1.154)	(3.464)	(0.991)
Quintile 3	-20.05***	-25.71***	-13.83***
	(1.159)	(3.452)	(0.999)
Quintile 4	-20.88***	-26.35***	-14.56***
	(1.164)	(3.522)	(1.005)
Quintile 5	-21.42***	-27.27***	-15.86***
	(1.150)	(3.457)	(1.021)
Year FE	Yes	Yes	No
Year × SIC2 FE	No	No	Yes
Value-weighted	No	Yes	No
Within SIC2 industry	No	No	Yes
N	24345	24330	24280
R^2	0.156	0.213	0.253

This table shows year-on-year variation in emissions by quintiles representing the level of emissions. The dependent variable is $|e_{t+1} - e_t|$, the absolute change in scope 2 greenhouse gas emissions, where emissions is measured in tons of CO_2 equivalents emitted per million dollars of revenue. We regress the dependent variable on quintile dummies of emissions intensity in year t. Estimated coefficients represent the difference in absolute year-on-year variation in emissions relative to the omitted category, quintile 1 representing brown firms. Standard errors are clustered at the firm level. In columns (1) and (2), quintiles are computed within each fiscal year, while in column (3), quintiles are computed within each fiscal year×SIC2 industry. Columns (1) and (2) include year fixed effects, and column (3) includes year and SIC2 industry fixed effects. In column (2), each observation is weighted by the firm's market capitalization as a fraction of total CRSP market size in the same year. *, **, and *** indicate significance at the 10%, 5%, and 1% levels, respectively. Standard errors are in parentheses and are clustered at the firm-level.

Table A3: Long run changes in emissions, controlling for interim returns

	5-year Changes in emissions			
	(1)	(2)	(3)	(4)
Brown × Annual return	-140.9***			
	(34.96)			
Neutral × Annual return	1.692			
	(6.084)			
Green × Annual return	-2.166			
	(3.739)			
Brown × Industry annual return		-232.3***		
		(63.41)		
Neutral × Industry annual return		-36.94***		
		(13.98)		
Green × Industry annual return		-24.19		
		(15.66)		
Brown × Low annual return			168.4***	
			(38.67)	
Neutral × Low annual return			3.098	
			(7.619)	
Green × Low annual return			4.898	
			(6.918)	
Brown × Low industry annual return				117.2***
				(33.12)
Neutral × Low industry annual return				29.50**
				(13.20)
Green × Low industry annual return				13.41
				(11.55)
p-value: Brown × X = Green × X	0.000	0.000	0.000	0.000
Interim return FE	Yes	Yes	Yes	Yes
Type FE	Yes	Yes	Yes	Yes
Year FE	Yes	Yes	Yes	Yes
SIC2 industry FE	Yes	Yes	Yes	Yes
N	12124	12216	12124	12216
R^2	0.138	0.138	0.130	0.130

This table repeats the analysis in Table 4 with the addition of control variables for the intersection between firm type (brown, neutral or green) and the firm or industry annual returns in the interim period, years t to $t+4$.

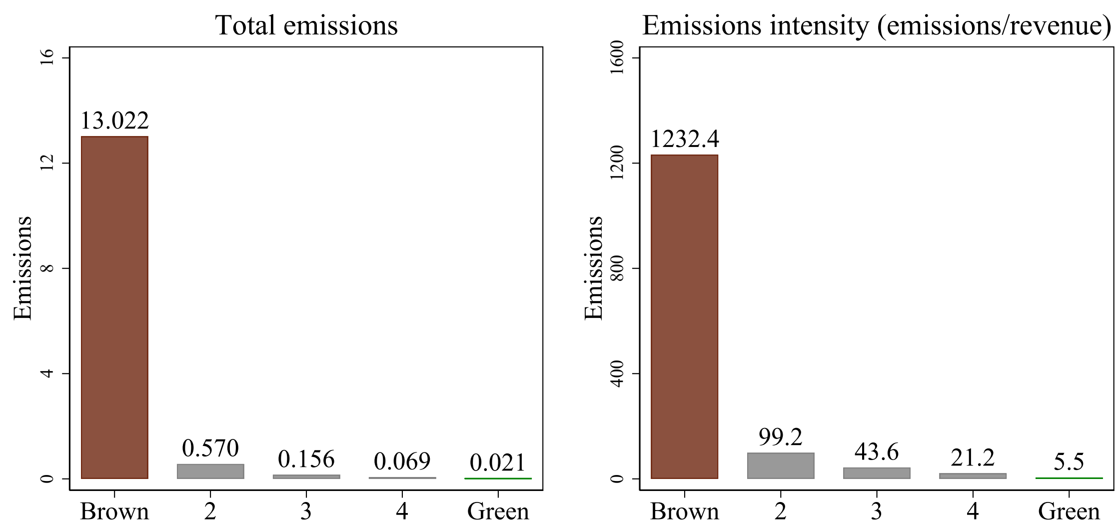
Table A4: Industry-level emissions, financial performance, and implied cost of capital (ICC)

	Changes in industry emissions			
	(1)	(2)	(3)	(4)
Brown × Industry annual return	-38.91			
	(27.40)			
Neutral × Industry annual return	0.704			
	(1.702)			
Green × Industry annual return	3.267			
	(2.298)			
Brown × Low industry annual return		186.5**		
		(79.33)		
Neutral × Low industry annual return		1.319		
		(5.204)		
Green × Low industry annual return		-3.196		
		(3.734)		
Brown × ΔIndustry ICC			2219.6*	
			(1202.8)	
Neutral × ΔIndustry ICC			8.855	
			(101.4)	
Green × ΔIndustry ICC			15.06	
			(78.21)	
Brown × ΔIndustry ICC composite				969.1**
				(440.3)
Neutral × ΔIndustry ICC composite				60.42
				(94.92)
Green × ΔIndustry ICC composite				50.66
				(46.44)
p-value: Brown × X = Green × X	0.154	0.026	0.074	0.044
Type FE	Yes	Yes	Yes	Yes
Year FE	Yes	Yes	Yes	Yes
N	935	935	925	893
R^2	0.0464	0.154	0.0652	0.0550

This table presents the relation between SIC2 industry-level changes in emissions intensity, and the industry's financial performance in the previous year. Emissions intensity is measured in tons of emissions per million dollars of gross output. Industry annual return and industry implied cost of capital are calculated as the average of the firm annual return and ICC, respectively, weighted by the firm's market capitalization as a fraction of total CRSP market size in the same year. The regressions are weighted by the gross output of the industry as a fraction of total gross output in each year. Below each regression, we report the p-value for the test of whether the coefficient for the interaction term containing the indicator for brown firms is equal to the coefficient for the interaction term containing the indicator for green firms. *, **, and *** indicate significance at the 10%, 5%, and 1% levels, respectively. Standard errors are in parentheses and are clustered at year.

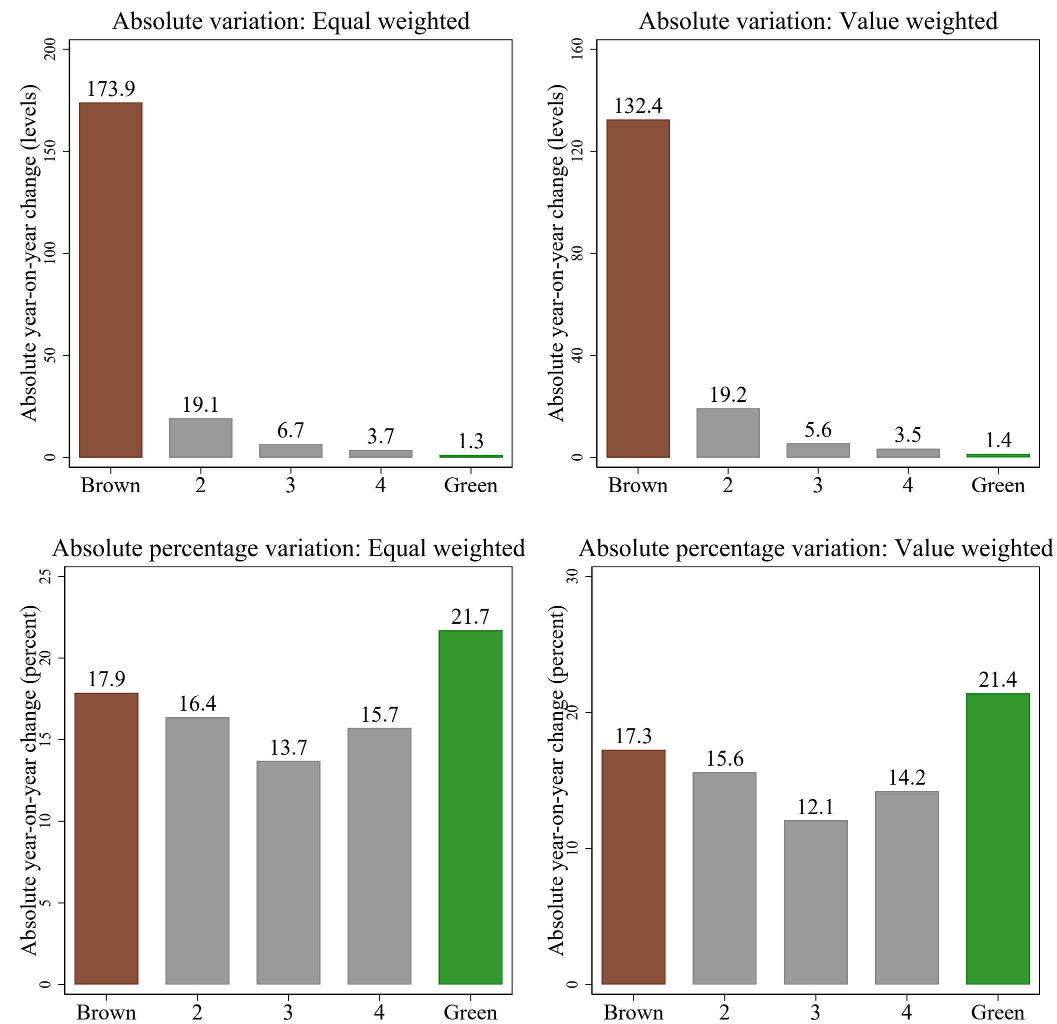
Appendix B: Result using non-estimated emission data

Figure B1: Average emissions by quintile: without estimated data



This figure replicates Figure 1 using the subsample of firm-year observations without Trucost model-estimated emissions data.

Figure B2: Absolute variation and percentage change in emissions: without estimated data



This figure replicates Figure 2 using the subsample of firm-year observations without Trucost model-estimated emissions data.

Table B1: Absolute change in emissions intensity by quintile: without estimated data

	Absolute changes in emissions		
	(1)	(2)	(3)
Quintile 2	-156.7***	-114.6***	-64.69***
	(10.75)	(11.71)	(9.906)
Quintile 3	-169.3***	-127.4***	-101.1***
	(10.69)	(11.10)	(11.53)
Quintile 4	-171.8***	-129.9***	-104.4***
	(10.61)	(11.13)	(10.36)
Quintile 5	-173.9***	-131.9***	-100.1***
	(10.57)	(11.18)	(9.757)
Year FE	Yes	Yes	No
SIC2 industry FE	No	No	Yes
Value-weighted	No	Yes	No
Within SIC2 industry	No	No	Yes
N	7523	7522	7355
R^2	0.261	0.283	0.430

This table replicates Table 2 using the subsample of firm-year observations without Trucost model-estimated emissions data.

Table B2: Emissions and financial performance: without estimated data

	Changes in emissions	
	(1)	(2)
Brown × Annual return	-76.14***	
	(12.39)	
Neutral × Annual return	4.807	
	(3.155)	
Green × Annual return	5.369	
	(3.364)	
Brown × Industry annual return		-169.7***
		(24.04)
Neutral × Industry annual return		0.700
		(10.43)
Green × Industry annual return		-1.643
		(10.56)
p-value: Brown × X = Green × X	0.000	0.000
Type FE	Yes	Yes
Year FE	Yes	Yes
SIC2 industry FE	Yes	Yes
N	7489	7514
R^2	0.0724	0.0790

This table replicates Table 3 using the subsample of firm-year observations without Trucost model-estimated emissions data.

Table B3: Long run changes in emissions and financial performance: without estimated data

	5-year Changes in emissions			
	(1)	(2)	(3)	(4)
Brown × Annual return	-154.1***			
	(43.26)			
Neutral × Annual return	-5.814			
	(7.517)			
Green × Annual return	-10.03			
	(8.878)			
Brown × Industry annual return		-304.2***		
		(76.75)		
Neutral × Industry annual return		-40.22		
		(26.19)		
Green × Industry annual return		-38.81		
		(27.45)		
Brown × Low annual return			109.7**	
			(48.97)	
Neutral × Low annual return			12.08	
			(14.04)	
Green × Low annual return			15.66	
			(13.52)	
Brown × Low industry annual return				66.93*
				(39.87)
Neutral × Low industry annual return				10.96
				(23.58)
Green × Low industry annual return				-3.938
				(19.72)
p-value: Brown × X = Green × X	0.001	0.000	0.045	0.042
Type FE	Yes	Yes	Yes	Yes
Year FE	Yes	Yes	Yes	Yes
SIC2 industry FE	Yes	Yes	Yes	Yes
N	4286	4292	4286	4292
R^2	0.191	0.196	0.185	0.184

This table replicates Table 4 using the subsample of firm-year observations without Trucost model-estimated emissions data.

Table B4: Emissions and financial distress: without estimated data

	Changes in emissions			
	(1)	(2)	(3)	(4)
Brown × Low interest coverage	3.802			
	(22.03)			
Neutral × Low interest coverage	-3.570			
	(4.149)			
Green × Low interest coverage	-3.824			
	(6.332)			
Brown × Low Z-score		37.89		
		(23.62)		
Neutral × Low Z-score		-2.933		
		(3.717)		
Green × Low Z-score		27.67*		
		(16.03)		
Brown × Low annual return			62.37***	
			(17.67)	
Neutral × Low annual return			-8.068**	
			(3.996)	
Green × Low annual return			-8.268*	
			(4.522)	
Brown × Low industry annual return				64.41***
				(16.73)
Neutral × Low industry annual return				-9.115
				(7.567)
Green × Low industry annual return				-7.533
				(6.201)
p-value: Brown × X = Green × X	0.737	0.715	0.000	0.000
Type FE	Yes	Yes	Yes	Yes
Year FE	Yes	Yes	Yes	Yes
SIC2 industry FE	Yes	Yes	Yes	Yes
N	6740	6298	7489	7514
R^2	0.0566	0.0603	0.0618	0.0633

This table replicates Table 5 using the subsample of firm-year observations without Trucost model-estimated emissions data.

Table B5: Emissions and implied cost of capital (ICC): without estimated data

	Changes in emissions			
	(1)	(2)	(3)	(4)
Brown × ΔICC	1173.4***			
	(252.8)			
Neutral × ΔICC	-41.35			
	(44.90)			
Green × ΔICC	-64.08			
	(48.74)			
Brown × ΔIndustry ICC		2045.8***		
		(413.3)		
Neutral × ΔIndustry ICC		-232.6		
		(166.8)		
Green × ΔIndustry ICC		-84.21		
		(131.6)		
Brown × ΔICC composite			569.4***	
			(207.0)	
Neutral × ΔICC composite			-77.40*	
			(40.60)	
Green × ΔICC composite			-57.95	
			(40.81)	
Brown × ΔIndustry ICC composite				1112.5***
				(193.9)
Neutral × ΔIndustry ICC composite				-79.51
				(57.03)
Green × ΔIndustry ICC composite				-3.964
				(56.18)
p-value: Brown × X = Green × X	0.000	0.000	0.003	0.000
Type FE	Yes	Yes	Yes	Yes
Year FE	Yes	Yes	Yes	Yes
SIC2 industry FE	Yes	Yes	Yes	Yes
N	4697	7485	1769	7084
R^2	0.0927	0.0692	0.0932	0.0695

This table replicates Table 6 using the subsample of firm-year observations without Trucost model-estimated emissions data.

Table B6: Interaction between leverage and real productivity shocks: without estimated data

	Changes in emissions	
	(1)	(2)
Brown × Low interest coverage × ΔIndustry ROA	-1267.7**	
	(548.9)	
Neutral × Low interest coverage × ΔIndustry ROA	-100.4	
	(162.4)	
Green × Low interest coverage × ΔIndustry ROA	363.9	
	(248.0)	
Brown × Firm leverage × ΔIndustry ROA		-2200.9**
		(934.7)
Neutral × Firm leverage × ΔIndustry ROA		9.841
		(215.3)
Green × Firm leverage × ΔIndustry ROA		557.2**
		(217.4)
p-value: Brown × X × Z = Green × X × Z	0.007	0.004
Type × ΔIndustry ROA	Yes	Yes
Type × Low interest coverage	Yes	No
Type × Firm leverage	No	Yes
Type FE	Yes	Yes
Year FE	Yes	Yes
SIC2 industry FE	Yes	Yes
N	6732	7486
R^2	0.0614	0.0628

This table replicates Table 7 using the subsample of firm-year observations without Trucost model-estimated emissions data.

Table B7: Dividend demand shocks to the cost of capital: without estimated data

	Changes in emissions	
	(1)	(2)
Brown × High dividend yield firm × Dividend demand	-119.2**	
	(49.30)	
Neutral × High dividend yield firm × Dividend demand	7.299	
	(4.832)	
Green × High dividend yield firm × Dividend demand	-7.791	
	(5.239)	
Brown × High dividend yield firm × High dividend demand		-60.65**
		(26.77)
Neutral × High dividend yield firm × High dividend demand		5.321**
		(2.414)
Green × High dividend yield firm × High dividend demand		-1.353
		(2.897)
p-value: Brown × X × Z = Green × X × Z	0.024	0.027
Type × Dividend demand	Yes	No
Type × High dividend demand	No	Yes
Type FE	Yes	Yes
Year FE	Yes	Yes
SIC2 industry FE	Yes	Yes
N	4396	4396
R^2	0.0819	0.0817

This table replicates Table 8 using the subsample of firm-year observations without Trucost model-estimated emissions data.