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 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 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 further show that brown firms face very weak 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 that are expected to grow to one-third of all assets under management by 2025.[1] While a variety of tactics have been employed, the dominant strategy involves making investments in firms that are perceived to be "green" (positive environmental impact) and divesting away from firms that are perceived to be "brown" (negative environmental impact). To the extent that sustainable investing[2] can meaningfully 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 consistent message from sustainable investors is the hope that their investments will make all firms more green. The success of the sustainable investing movement 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 a firm's change in impact due to a change in its cost of capital. Without knowledge of the relative 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, 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. Green firms exhibit low variability in impact and close-to-zero impact elasticity with respect to changes in their cost of capital. In contrast, brown firms have approximately 260 times as much environment impact as similarly-sized green firms, and have substantially greater scope for change. 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. We further show that the dominant sustainable investing strategy provides very weak incentives for brown firms to become more green. Instead, due to a mistaken focus on *percentage* changes in emissions, the sustainable investing movement primarily rewards green firms for economically trivial reductions in their already low levels of

[1] https://www.bloomberg.com/company/press/esg-may-surpass-41-trillion-assets-in-2022-but-not-without-challenges-finds-bloomberg-intelligence

[2] We use "sustainable investing" as an umbrella term to refer to investment strategies that seek to improve firm 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.

emissions.

Whether sustainable investing over the past several decades has had a major impact on firm cost of capital is open to debate. Chava (2014), van der Beck (2021), Kacperczyk and Peydró (2022), Pástor et al. (2022), Gormsen et al. (2023), and Green and Vallee (2022) present empirical evidence of green firms having lower cost of capital in both debt and equity markets, whereas Teoh et al. (1999) and Berk and van Binsbergen (2021) argue that other investors can offset sustainable investment flows. In this paper, we do not take a strong stand on whether sustainable investing has already impacted firm cost of capital. Rather, we believe that with $35 trillion in committed assets, including $4 trillion in the rapidly growing green debt market,[3] it is important to consider what would happen if the movement succeeds. Our paper suggests that the best case scenario is one where the dominant sustainable investing strategy, in its present form, has not yet succeeded in shifting firms' cost of capital.

A simple case study may help illustrate our paper's intuition. 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, which is about 1 ton per million dollars of revenue.[4] At the opposite extreme lies Martin Marietta Materials, another S&P 500 firm that supplies heavy building materials. Amongst ESG ratings providers, Martin Marietta is uniformly considered poor. In 2021, it emitted about 5.1 million tons of carbon, corresponding to about 1,000 tons per million dollars of revenue.[5] 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 were able to 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 Marietta 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 significant green investments to cut its emissions per ton of cement from 0.84 in 2016 to

[3] Ibid.

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

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

0.77 in 2019. Martin Marietta has also considered a number of green investments for future adoption, although the firm currently deems them unprofitable absent additional financial incentives.[6] Similarly, 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 relatively more front-loaded cash flows. Simply reversing its efficiencies per dollar on carbon emissions 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 the intuition of this example is reflective of the broader data. We measure firm environmental impact using greenhouse gas (e.g., carbon) emissions, defined as total emissions scaled by output, because it is a standardized measure commonly used by sustainable investors that directly contributes to the risk of global climate change. The importance of carbon emissions to sustainable investors is also reflected in recent SEC communications concerning mandatory disclosure of emissions in the portfolio holdings of all funds that consider environmental factors.[7] Indeed, a recent cover story in *The Economist* argued that emissions are so important that they should be the sole focus of sustainable investors.[8]

We begin by showing that brown firms have much greater levels of emissions and year-to-year variability than green firms. Measures of variability provide a useful upper bound on the absolute value of a firm's impact elasticity; variability that is close to zero implies that the impact elasticity must also be 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. We show that 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 levels from year to year. The average absolute annual *change* in emissions for a brown firm is equal to the average *level* of emissions from 35 green firms combined.

Next, we examine the impact elasticity of green and brown firms to changes in their cost of capital.

[6]For example, the firm cites the friendly regulatory environment in Europe for green investment and argues that it would be unprofitable to implement similar changes in the US without such regulation.

[7]"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

[8]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

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. We explore potential violations of this assumption later in this paper.

Across a variety of tests, we find that brown firms have greater negative impact elasticity than green firms. First, brown firms exhibit greater reductions in their emissions following improvements in their real or financial performance. Stronger firm performance likely eases the firm's financial constraints and lowers the firms' cost of capital. To establish causality, we examine the relation between firm emissions and the firm's industry performance, calculated excluding the focal firm. The intuition is that industry performance shocks strongly affect firm-level performance and financing costs, but individual firm choices of emissions should not affect the industry average performance calculated excluding the focal firm. We find that brown firms are much more elastic to industry shocks than green firms.

Second, we examine how firm emissions respond to financial distress shocks, 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. Highly leveraged firms should be extra sensitive to industry shocks because negative performance increases their probability of bankruptcy, leading to a larger increase in their cost of capital. We find the largest increase in emissions after a negative industry shock occurs among brown firms that are highly leveraged prior to the shock. This result helps to identify the effect of an increase in the cost of capital as distinct from the general effects of negative firm or industry performance.

Third, we measure impact elasticity with respect to the firm's implied cost of capital (ICC). The ICC is the internal rate of return that equates the firm's market value to the present value of its expected future cash flows. A higher ICC corresponds to higher cost of capital. Across a variety of ICC measures, we find that brown firms exhibit a large negative impact elasticity with respect to their ICC while green firms exhibit elasticities close to zero. To establish causality, we examine the relation between firm emissions and industry ICC, calculated excluding the focal firm, and find similar results.

These empirical patterns are consistent with basic corporate finance theory. Brown firms likely face a choice between dark-brown investment projects (e.g., continuing or expanding existing high-pollution operations, or cutting corners on pollution abatement) and light-brown investments (e.g., shifting toward cleaner production or green energy). Because the light-brown investment 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. 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. This intuition is most similar to the model in Lanteri and Rampini (2023), which shows that financial constraints cause firms to choose dirty over clean technology.[9] In contrast, a green firm likely operates in a line of business (e.g., insurance in the case of Travelers) where the firm cannot generate substantial environmental externalities regardless of which investment projects it chooses 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 investing provides financial incentives for firms to become more green. Specifically, brown firms may choose to become more green if sustainable investors reward their change by lowering their cost of capital in the future.

We believe that a sustainable investing strategy targeted at changing firms' incentives could be promising. However, we show that the dominant sustainable investing strategy in practice provides no such incentives. Sustainable investment funds indeed overweight firms that have improved their impact over the past several years, consistent with these funds rewarding firms that 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 (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.

The distinction between percentage and level changes is important because of large scale differences in levels of emissions across firms. A 100% reduction in emissions by a green firm is far less

[9] In addition, Thomas et al. (2022) show that firms cut back on pollution abatement costs to meet earnings targets. The simple intuition here is also similar in spirit to a specialized model presented in Eisfeldt and Rampini (2007), which shows that financial distress or an increase in the cost of capital induces firms to favor investment in used capital (e.g., older technologies or existing projects) that is cheaper up front and may require greater maintenance costs in the future. The ability of brown firms to choose between projects with more or less front-loaded cash flows is underscored by recent evidence from Gilje et al. (2020) showing 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.

economically meaningful than a similarly-sized brown firm reducing its emissions by a mere 1%. The focus on percentage reductions is exacerbated by popular net-zero emissions targets (see e.g., Hong et al. (2021)), which entail a large percentage reduction in emissions and are easier to achieve for green firms with low levels of emissions ex ante. 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.[10]

Overall, we show that the dominant sustainable investing strategy targets green firms with little scope to change their environmental impact. To the extent that sustainable investing increases the cost of capital for brown firms or pushes them toward financial distress, brown firms react by becoming more brown. Because it measures changes in impact in the wrong units, the dominant sustainable investment strategy also provides weak financial incentives for brown firms to become less brown. However, our analysis represents only a critique of the dominant sustainable investing strategy. 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.[11]

Before proceeding, it is important to recognize that sustainable investors can have different objectives. We show that the dominant sustainable investing strategy can be counterproductive relative to the widespread practitioner goal of smoothly transitioning to a green economy. A "transition" objective strives to save the environment while minimizing the decrease in economic output.[12] 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 firm 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

[10] Related evidence from Hartzmark and Sussman (2019), Heeb et al. (2022), and Bauer et al. (2021) has shown 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.

[11] 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). Other promising alternatives to the dominant sustainable investing include supplementing or replacing sustainable investing with regulation and carbon pricing (e.g., Pedersen (2023), Martinsson et al. (2023).

[12] Or perhaps even increasing output. As summarized by a recent NYT 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

output.[13] The dominant sustainable investing strategy, contrary to its potential counterproductive effect on a transition objective, 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.

If the dominant strategy were able to achieve this degrowth goal, the result would be a loss of output in critical sectors. Brown firms operate in industries such as agriculture, transportation, and building materials, which produce outputs that are essential to society and currently lack practical green alternatives. In the absence of green substitutes for entire brown sectors, sustainable investors could contribute to the greening of a sector by investing in the greener firms *within* that sector and divesting from the less green ones. However, we show that sustainable investors generally divest away from brown industries entirely. To see why this strategy could be costly, suppose the agricultural sector produced less food because it is starved of capital by sustainable investors. Growth of green industries such as insurance and legal services sectors would not offset this loss because the products are not substitutable. Under the dominant strategy, there would be less emissions, but also less food.[14]

Finally, we acknowledge that the dominant sustainable investing strategy could have long run consequences beyond what we capture in our analysis of emissions. For example, sustainable investors may aim to incentivize R&D in green technology that will be implemented years into the future. Offering long run incentives for green R&D could be an effective investment strategy. However, this approach does not describe the bulk of sustainable investing in practice.[15] According to Cohen et al. (2020), brown energy sector firms tend to be excluded from sustainable portfolios, despite the fact that these firms produce the most highly-cited green patents. In contrast, green industries such as insurance, healthcare, and financial services, have a much lower likelihood of developing impactful green technology.

Our evidence that brown firms have a negative impact elasticity is consistent with earlier evidence

[13]The NYT 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."

[14]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 fully substitutable. If instead one interprets these models as within an industry with substitutable products (e.g. within the agricultural industry), then the model intuition holds.

[15]For instance, Blackrock and Vanguard designate financial investment aimed at promoting green innovation as “impact” strategies. While 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. Bolton et al. (2022) further argues that green innovation has theoretically ambiguous and empirically weak effects on future emissions.

in Hong et al. (2012) showing that firms do more social good when they are doing well and financially unconstrained. We differ in focus by showing that the magnitude of the relation between firm 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 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 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 counter-productive instead of merely ineffective as argued by some of the existing research.

Our findings are also related to the empirical literature highlighting problems in the current system of evaluating firm ESG and sustainability (e.g., Berg et al. (2022)). Our analysis shows that ESG ratings are 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 why green firms do not improve—green firms have little scope to improve, even when incentivized to do so.

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

II. Framework: Impact Elasticity

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

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

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 specifically 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 currently provides very weak financial incentives for brown firms. Instead, sustainable investors and ESG ratings primarily reward firms that are already green for economically trivial, but large percentage, reduction in their emissions.

Second, we follow standard practice and measure firm environmental impact as a firm's emissions intensity, equal to 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.[16] 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, firms should assess potential investment projects using a project-specific cost of capital that reflects project-specific risk rather than a firm-wide cost of capital. The impact elasticity measure can accommodate a project-specific valuation method. We assume that firm-level shocks to the cost of capital shifts the firm's project-specific discount rates equally across all projects. We leave the study of the effectiveness of alternative sustainable investing strategies, such as those that subsidize specific green investment projects, to future research. For now, we note that 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.

A. Impact elasticities of brown and green firms

While the primary contribution of this paper is to provide empirical evidence, we present a very simple stylized model here to illustrate one, non-exclusive, reason why brown and green firms might differ in their impact elasticities. For a more detailed model with similar intuitions, see Lanteri and Rampini (2023).

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

[16] 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. In unreported empirical results, we confirm that unscaled emissions of firms in our data decline with the cost of capital, as predicted by theory. Thus, the dominant sustainable investing strategy is not counterproductive relative to a "degrowth" objective which seeks to lower emissions irrespective of maintaining output levels.

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 greater 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, or switching to greener production methods. Because G involves a switch to new technology, it has a relatively higher up-front cost and relatively more backloaded cash flows compared to B.

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, in the absence of sustainable investing, the firm is indifferent between B and G:

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

Suppose that there is an increase $\delta > 0$ in the cost of capital for all investments by the brown firm. 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.

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.[17] We use data on scope 1 and 2 emissions. Scope 1 emissions are the most directly tied to the firm as they represent 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.

Accounting data concerning firm financial and real performance, leverage, earnings, and revenue are obtained from the Compustat database. Price and return information is taken from the Center for Research in Securities Prices CRSP database. Data relating to ESG ratings comes from MSCI ESG Ratings (the data was formerly 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. Therefore, we follow a convention commonly used by ESG ratings companies and prior 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.

Analysis on the holdings of green investment funds are based on data generously shared by the authors of Cohen et al. (2020). We categorize an investment fund as green if it is defined as green based on any of the measures described in the Cohen et al. (2020) paper. Specifically, we classify funds as green if the fund name contains "ESG" or "Green" or if the fund is classified as an sustainable

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

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 green 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 green funds and 2% of the value of the total market portfolio, then we would estimate that green 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 Gebhardt et al. (2001) (GLS) mechanical ICC as our preferred measure of the ICC. This measure is also similar to those used in prior papers in the ESG literature (e.g., Chava (2014)). As shown in Lee et al. (2021), estimation of firm-level ICC is difficult and suffers from substantial noise due to the necessity of making assumptions about expected future cash flows and non-unique numerical solutions. To mitigate the problems of noise, we also 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 is still 155 times as large as in the 10th percentile. The absolute value of 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 emissions in far less skewed. However, as we will show, percentage changes in emissions are a poor measure of the true change in firm 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. Variability in firm impact

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 provides a useful bound for our ultimate measure of interest, the impact elasticity, because variability that is close to zero implies that the impact elasticity must also be close to zero. Variability is also useful because one reasonable estimate for how much a firm can change its impact is how much it has changed in the past.

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 carbon emissions (unscaled), the average brown firm releases more than 1,700 times as much carbon as the average green firm. Of course, these differences in carbon emissions across firms could be due to differences in firm size; it would be natural for larger firms to emit more carbon. 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 carbon per unit of sales 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 dramatic differences in carbon emissions across the five quintiles shown in Figure 1 indicates that any analysis focusing on 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 carbon impact would be equivalent to the average green firm increasing its emission by 26,000%.

Thus, instead of focusing on percentage changes, we focus on the annual absolute level change in emissions (always scaled by revenues). 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 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 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; the change in absolute emissions by brown firms exceeds that of firms in quintile 2 by 163 tons. In other words, firms we classify as neutral are more similar to green firms than brown firms.

A potential concern with the results in Column 1 of Table 2 is that the extreme differences in emission is driven by small firms that have high emissions per unit of revenue, but low overall emissions due to their small size. To account for such a possibility, in Column 2, we weight observations by firm market value as a fraction CRSP 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. We continue to 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 (direct emissions from the company's owned or controlled sources) and scope 2 (indirect emissions from purchased energy) 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 Figure 3, we show that differences in variability in emissions across brown and green firms disappear if we measure changes in emissions using percentage changes instead of level changes. Across three possible specifications, green firms have close to or greater percentage variability in their emissions compared to brown firms. However, 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 or shocks to the cost of capital. 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 becoming more green (i.e., green firms have a negative impact elasticity), and brown firms react to a higher cost of capital by becoming more green (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 society. 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.

We begin by examining the relation between changes in emissions and changes in firm performance. A positive performance shock is likely to ease the firm's access to financing. Likewise, a negative performance shock should increase the firm's shadow cost of capital.

One limitation of simply looking at the relation between firm emissions and firm performance is that any measured correlation could be driven by reverse causality (if becoming more green causes the firm to perform differently), or by omitted variables bias (e.g., if the arrival a talented new green-oriented CEO causes both a shift in green production and firm performance). To better estimate the causal effect of firm performance on firm emissions, we examine the relation between firm emissions and the firm's industry value-weighted average performance, calculated excluding the focal firm. The intuition is that industry performance shocks strongly affect firm-level performance, but individual firm choices should not have a strong effect on the industry average performance calculated excluding the focal firm.

In Table 3, we find that brown firms are significantly more elastic to shocks to firm 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 -49.95 implies that a 10% financial return for brown firms is associated with an approximate 5 tons per million dollar of revenue reduction in emissions. 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 the firm 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.

In Columns 3 and 4 of Table 3, we repeat the analysis using changes in real firm or industry performance, with real performance measured as return on assets. Column 3 shows a large negative and significant coefficient on ROA for brown firms of -133.1, implying that a 10% increase in firm ROA is associated with a decline in emissions by brown firms that is equal to 2.6 times the average level of emission by green firms. In contrast, neutral and brown firms display smaller positive changes in emissions following an increase in ROA. In Column 4, we find qualitatively similar patterns using changes in industry ROA instead of firm ROA, consistent with a causal link between real performance shocks and differential changes in emissions across brown and green firms.

In all specifications in Table 3, brown firms pollute less following positive performance shocks and pollute more following negative performance shocks. In contrast, green firms have smaller and inconsistently signed changes in emissions. We can also 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). In some specifications, green firms even exhibit the opposite relation; they increase emissions intensity following positive performance shocks.

Perhaps the most common refrain from sustainable investors on why they avoid brown firms is that they wish to starve those firms of capital, thereby forcing them into financial distress. If this results in brown firms becoming more green then the strategy would have the desired effect. Before getting to the empirical results, we note that there are reasons ex-ante to be skeptical of this line of argument. 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 very discount rate, such that the firm will favor investments offering short term gains. Since transitioning to greener production by brown firms usually entails 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.

In Table 4 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 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 (a commonly-used predictor of the firm's 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 or real performance 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 industry performance (calculated excluding the focal firm) is in the bottom decile of our sample.

Across all six specifications in Table 4, 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 for distress. P-value tests of equality shows that we can reject the null that brown and green firms have equal changes in emissions after experiencing distress. The coefficient magnitudes imply that brown firms increase their emissions by approximately 20 to 50 tons per million in revenue after experiencing a distress shock associated with being in the lowest decile of some measure (interest coverage, Z-score, financial returns, or ROA) 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 increase their emissions by at least four times the level of emissions of the average green firm.

Highly leveraged firms may be extra sensitive to performance shocks because negative performance increases their probability of bankruptcy, leading to costly financial distress. These highly leveraged 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. In Appendix Tables A4 and A5, we show that the relationship between emissions and performance (measured as firm or industry ROA) is significantly stronger for brown firms with low interest coverage or higher debt-to-value ratios. These results help to identify the effect of financial distress as distinct from the general effects of negative firm or industry 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 causing brown firms to become more brown.

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 firm and industry performance. We can also attempt to directly measure the implied cost of capital (ICC) for each firm-year. Before proceeding, we stress that these tests should be viewed as a complement rather than as a replacement for our previous results because direct estimates of a firm's cost of capital have been shown to be noisy. Lack of unique numerical solutions along with small differences in the timing of measurement and assumptions regarding the path of future cash flows can lead to large differences in estimates of the ICC (for more details, see Lee et al. (2021)).

The ICC is the internal rate of return that equates the firm's market value to the present value of its expected future cash flows, based on a valuation model that can vary depending on the researcher's chosen set of assumptions. Thus, the ICC represents the expected return to investors of the firm and the firm's cost of raising capital from the same investors. 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 5, we regress the firm's change in emissions intensity on the firm's change in implied cost of capital 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 less significant changes in their emissions following changes to their cost of capital. This is true both using the GLS as well as the composite ICC estimates. For example, the coefficient in Column 1 implies that brown firms increase emission by 68 tons per million follow a 10 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, while neutral and green firms have smaller impact elasticities closer to zero.

Similar 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 a talented new green-oriented 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 elasticity of brown firm emissions intensity with respect to industry ICC, and an smaller and insignificant relation for neutral and green firms. These patterns are robust to using the equal-weighted average for four ICC variants.

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, 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 in the future.

We believe that developing an sustainable investing strategy that motivates brown firms to become more green is a promising agenda. 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 firms who 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 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 nuanced results which ultimately imply very weak 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.

Popular ESG environmental ratings similarly reward percentage reductions in emissions rather than level reductions in emissions. For instance, the Financial Times recognized firms as climate leaders based on a ranking of percentage reductions in emissions intensity (see Figure 4). Unsurprisingly, the top 10 climate leaders all started with emissions intensity levels below 35 tons per million dollars of revenue. In contrast, brown firms in our sample have emissions intensity levels averaging 1,308 tons per million. It is much more costly for a brown firm with high levels of pollution to have a similarly large percentage reduction in emissions. Thus, the dominant sustainable investing strategy primarily rewards firms that are already green that have large percentage, but economically trivial, reductions in emissions.

Using data generously shared by Cohen et al. (2020), we classify funds as green 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 green funds, we compare the holdings of two portfolios: the aggregated holdings of all green 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 green funds using its "overweight," defined as the difference between the stock's portfolio weight in the aggregate green fund portfolio and the market portfolio, scaled by its weight in the market portfolio.

In Table 6, we regress the firm's overweight in the aggregate green 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 firm environmental impact. 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 change in emissions as the percentage change. We argue that this is the incorrect measure of the change in real firm environmental impact. As shown in Figure 3, green firms are associated with large absolute percentage changes. These large percentage changes in emissions by green 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 6 show that the current level of emissions and percentage changes in emissions are both strong predictors of green 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 7, 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 very 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%. It is also much easier for a green firm to purchase a small quantity of carbon offsets to completely offset its initially low level of emissions and become carbon neutral. However, this 100% reduction in emissions is far less economically meaningful than a brown firm reducing its emissions by a mere 1%.

Perhaps most surprisingly, we find in Table 8 that sustainable investment funds reward green firms more than brown firms for the same percentage reduction in emissions. They should do the reverse and reward brown firms more for the same percentage reduction in emissions. This additional mistake 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.

D. Product substitutability and degrowth

Our analysis has shown that an increase in the the cost of capital for brown firms has the direct effect of making them pollute more per unit of output. Such an effect is counterproductive relative to a smooth "transition" objective that seeks to reduce brown firms' emissions intensity. However, as discussed 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. Thus, raising the cost of capital for brown firms is not counterproductive relative to a more radical "degrowth" objective, which seeks to reduce emissions without regard to losses in output.[18]

The welfare cost of a decrease in output from brown firms disfavored by sustainable investors depends on whether that loss in brown output can by substituted with growth in output from green firms favored by sustainable investors. As discussed previously, reducing or eliminating the output from entire brown sectors such as agriculture, transportation, and building materials may be very costly, because such output cannot be substituted with output from green sectors such as insurance, healthcare, finance, and legal services. In the absence of green substitutes for entire brown sectors, sustainable investors could contribute to the greening of a sector by investing in the greener firms *within* that sector and divesting from the less green ones.

In this section, we explore how sustainable investors allocate their investments across industries. To avoid loss of output from an entire sector without viable substitutes, sustainable investment should occur based on sorting *within* an industry. For example, given people can't 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 underweight relatively brown firms within agriculture and overweight relatively green firms within agriculture. Importantly, this would not lead to underweighting of the agriculture industry as a whole.

When examining the data though, this is not what we find. We show that sustainable investors on average overweight entire green industries and underweight brown industries. Continuing with the agriculture example, the aggregate green 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%. Further, there is no

[18]While there are proponents of a degrowth strategy, degrowth adherents are typically viewed misguided ideologues. This may explain why an often used trope in popular entertainment is a degrowth villain attempting to wipe out humanity for the good of the planet. Recent examples include Thanos in the Avengers, 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.

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 green funds at 232% relative to its market cap) attempted to grow crops, it is unlikely it would be able to grow crops with lower emissions intensity than firms already in the agricultural crop industry.

Consistent with this example, Figure 5 presents a binscatter plot of the relation between each SIC2 industry's emissions and the extent to which the industry is overweighted in the aggregate green portfolio. The plot shows a strong negative slope. Industries with high emissions are significantly underweighted by green funds and industries with low emissions tend to be overweighted.[19]

Of course, 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 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 the dominant investing strategy, in its current form, may instead result in costly degrowth.

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 impact at best. Increasing financing costs for brown firms leads to large negative changes in firm impact. We further show that the dominant sustainable investing strategy provides very weak 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.

Altogether, our results imply that the best case scenario is the one where the dominant sustainable investing strategy has not yet shifted firms' cost of capital. To the extent that such a strategy succeeds in changing firms' cost of capital, it would have the counterproductive effect of making brown firms

[19] Among industries with very low emissions, there exists dispersion in how these industries are weighted in the aggregate green portfolio. This dispersion likely reflects the reality that sustainable investors care about other factors beyond emissions, such as the social and governance components of ESG. Nevertheless, the Figure shows a clear negative slope in which the aggregate green fund underweights industries with high emissions.

more brown without making green firms meaningfully more green.

Our findings and conclusions are not meant as a negative assessment of all possible sustainable investment strategies. Rather, they highlight potential problems with the most popular sustainable investment strategy to date, which divests from brown firms and invests in green firms, while offering weak incentives for brown firms to improve. Our analysis suggests that sustainable investing flows and engagement that targets the incentives of green firms would be more effective if targeted at brown firms.

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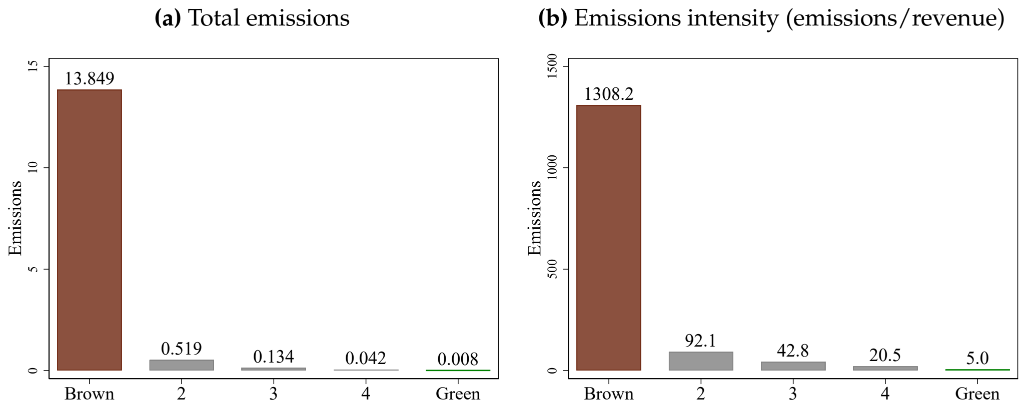
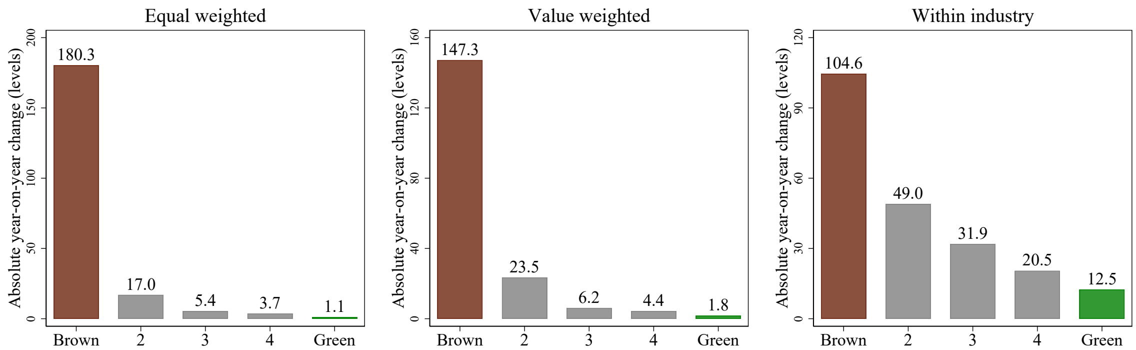
Figure 1: Average GHG emissions in each quintile



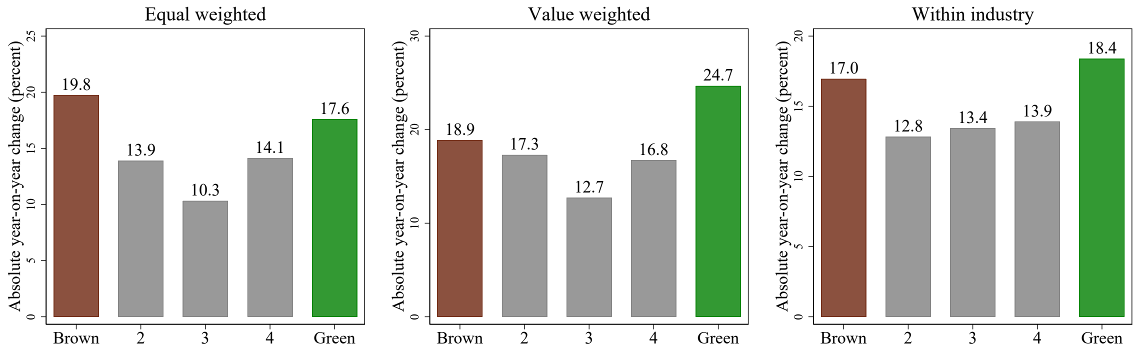
This figure plots the average emissions of scope 1 and scope 2 greenhouse gases by firms, sorted into quintiles within each year, with quintile 1 representing brown firms and quintile 5 representing green firms. In Panel (a), emissions are measured as million tons of CO_2 equivalents. In Panel (b), emissions are measured as tons of CO_2 equivalents emitted per million dollars of revenue.

Figure 2: Absolute variation of emissions intensity by quintile



This figure plots year-on-year variation in emissions across quintiles for the level of emissions. Variation in emissions is $|e_{t+1} - e_t|$, the absolute change in scope 1 and scope 2 greenhouse gases emissions intensity, where emissions intensity is measured in tons of CO_2 equivalents emitted per million dollars of revenue. Absolute changes are winsorized at the 1% level. In the left and middle panels, quintiles are computed within each fiscal year. In the right panel, quintiles are computed within each year×SIC2 industry. Observations in the left and right panels are equal weighted. In the middle panel, observations are weighted by the firm's market capitalization as a fraction of total CRSP market size in the same year.

Figure 3: Absolute percentage variation of emissions intensity by quintile



This figure plots year-on-year percentage variation in emissions across quintiles for the level of emissions. Variation in emissions is $|\frac{e_{t+1}-e_t}{e_t} \times 100|$, the absolute percentage change in scope 1 and scope 2 greenhouse gases emissions intensity, where emissions intensity is measured in tons of CO_2 equivalents emitted per million dollars of revenue. In the left and middle panels, quintiles are computed within each fiscal year. In the right panel, quintiles are computed within each year×SIC2 industry. Observations in the left and right panels are equal weighted. In the middle panel, observations are weighted by the firm's market capitalization as a fraction of total CRSP market size in the same year.

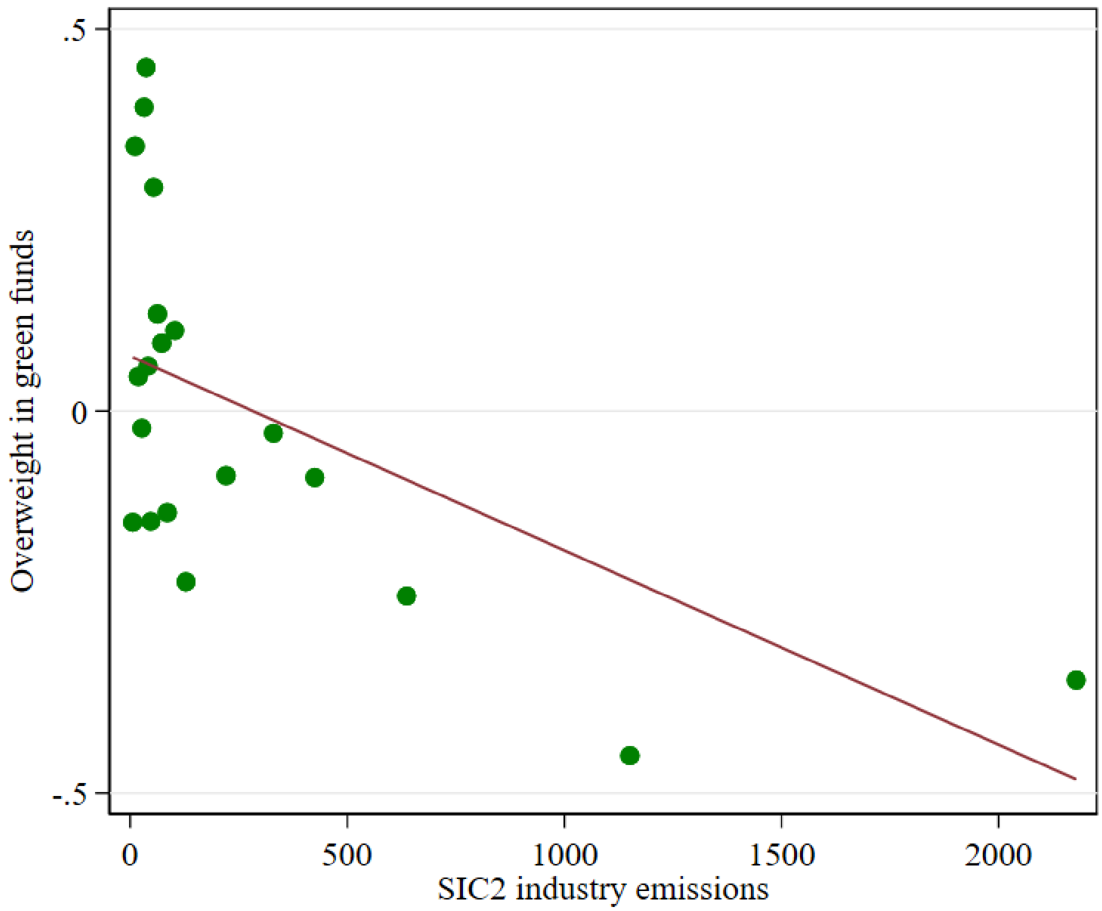
Figure 4: Focus on percentage reductions in emissions intensity

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 35 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 5: Green 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 green fund portfolio. Observations underlying the estimate 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 green 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	0.1343	0.5298	-0.3835	0.0676	0.6227
Industry annual return	0.1452	0.2213	-0.1106	0.1370	0.4000
ΔROA	-0.0022	0.0896	-0.0747	-0.0000	0.0649
ΔIndustry ROA	-0.0008	0.0238	-0.0230	0.0010	0.0225
ΔICC	0.0008	0.0265	-0.0265	-0.0000	0.0300
ΔIndustry ICC	-0.0002	0.0132	-0.0127	-0.0007	0.0151
ΔICC composite	0.0085	0.0631	-0.0527	0.0022	0.0795
ΔIndustry ICC composite	0.0030	0.0346	-0.0285	-0.0003	0.0407

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. ΔROA is the annual change in firm ROA. ΔIndustry ROA is the annual value-weighted change in industry ROA, 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 $|e_{t+1} - e_t|$, the absolute change in scope 1 and scope 2 greenhouse gases 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) 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 firm performance

	Changes in emissions			
	(1)	(2)	(3)	(4)
Brown × Annual return	-49.95***			
	(8.150)			
Neutral × Annual return	1.260			
	(0.944)			
Green × Annual return	1.245			
	(1.101)			
Brown × Industry annual return		-72.84***		
		(16.96)		
Neutral × Industry annual return		-0.315		
		(5.014)		
Green × Industry annual return		1.445		
		(5.487)		
Brown × ΔROA			-133.1***	
			(37.82)	
Neutral × ΔROA			9.273***	
			(3.112)	
Green × ΔROA			7.486	
			(5.461)	
Brown × ΔIndustry ROA				-222.2**
				(104.7)
Neutral × ΔIndustry ROA				43.49*
				(24.51)
Green × ΔIndustry ROA				140.8***
				(40.65)
p-value: Brown × X = Green × X	0.000	0.000	0.000	0.001
Type FE	Yes	Yes	Yes	Yes
Year FE	Yes	Yes	Yes	Yes
SIC2 industry FE	Yes	Yes	Yes	Yes
N	23818	24271	21863	24262
R^2	0.0493	0.0432	0.0421	0.0392

This table shows changes in firms' emissions following changes in firm or industry performance. The dependent variable is $e_{t+1} - e_t$, the change in scope 1 and scope 2 greenhouse gases emissions, 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 financial or real performance in the previous year and indicators for whether the firm is brown, neutral, or green. All other variables are as define 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 coefficients on the interaction with brown firms and the interaction with green firms are equal. *, **, 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: Emissions and financial distress

	Changes in emissions					
	(1)	(2)	(3)	(4)	(5)	(6)
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			53.74***			
			(10.88)			
Neutral × Low annual return			-4.854***			
			(1.365)			
Green × Low annual return			-4.225**			
			(1.733)			
Brown × Low industry annual return				51.19***		
				(11.17)		
Neutral × Low industry annual return				-1.077		
				(3.303)		
Green × Low industry annual return				0.202		
				(3.001)		
Brown × Low ΔROA					29.80**	
					(11.80)	
Neutral × Low ΔROA					-4.523***	
					(1.085)	
Green × Low ΔROA					-2.003	
					(1.390)	
Brown × Low ΔIndustry ROA						20.27**
						(8.736)
Neutral × Low ΔIndustry ROA						-2.474
						(1.618)
Green × Low ΔIndustry ROA						-9.815***
						(1.732)
p-value: Brown × X = Green × X	0.041	0.009	0.000	0.000	0.007	0.001
Type FE	Yes	Yes	Yes	Yes	Yes	Yes
Year FE	Yes	Yes	Yes	Yes	Yes	Yes
SIC2 industry FE	Yes	Yes	Yes	Yes	Yes	Yes
N	19747	19069	23818	24271	21863	24262
R^2	0.0404	0.0425	0.0440	0.0433	0.0413	0.0392

This table shows changes in firms' emissions following financial distress. The dependent variable is $e_{t+1} - e_t$, the change in scope 1 and scope 2 greenhouse gases emissions, 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. 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 coefficients on the interaction with brown firms and the interaction with green firms are equal. *, **, 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 implied cost of capital (ICC)

	Changes in emissions			
	(1)	(2)	(3)	(4)
Brown × ΔICC	680.6***			
	(140.8)			
Neutral × ΔICC	-14.36			
	(19.15)			
Green × ΔICC	-18.40			
	(16.90)			
Brown × ΔIndustry ICC		452.8*		
		(240.9)		
Neutral × ΔIndustry ICC		-26.56		
		(62.93)		
Green × ΔIndustry ICC		-44.19		
		(57.17)		
Brown × ΔICC composite			418.3***	
			(107.3)	
Neutral × ΔICC composite			-10.35	
			(18.38)	
Green × ΔICC composite			-22.82	
			(16.78)	
Brown × ΔIndustry ICC composite				402.1***
				(122.8)
Neutral × ΔIndustry ICC composite				19.59
				(23.34)
Green × ΔIndustry ICC composite				38.02*
				(22.98)
p-value: Brown × X = Green × X	0.000	0.042	0.000	0.003
Type FE	Yes	Yes	Yes	Yes
Year FE	Yes	Yes	Yes	Yes
SIC2 industry FE	Yes	Yes	Yes	Yes
N	15978	24162	6801	22809
R^2	0.0521	0.0389	0.0639	0.0390

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 $e_{t+1} - e_t$, the change in scope 1 and scope 2 greenhouse gases emissions intensity, 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 coefficients on the interaction with brown firms and the interaction with green firms are equal. *, **, 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: Portfolio holdings of green funds and changes in emissions

	Overweight in green 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 green investment funds and emissions varies depending on how changes in emissions are measured. The dependent variable measures the extent to which a firm is over-weighted by green funds relative to the stock's weight in a value-weighted market portfolio (overweight is calculated as $\frac{w_{GF}-w_{mkt}}{w_{mkt}}$, where w_{GF} is the stock's weight in aggregate green fund 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 7: 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 how the relation between ESG environmental ratings and emissions varies depending on how changes in emissions are measured. 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 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 8: Sustainable investing and changes in emissions by firm type

	Overweight in green 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 (changes in percents)	-0.0142		-0.133*	
	(0.0734)		(0.0698)	
Neutral × $\Delta_{t,t-1}$Emissions (changes in percents)	-0.161***		-0.121**	
	(0.0553)		(0.0538)	
Green × $\Delta_{t,t-1}$Emissions (changes in percents)	-0.199***		-0.146**	
	(0.0574)		(0.0589)	
Brown × $\Delta_{t,t-2}$Emissions (changes in percents)		0.00814		-0.0836
		(0.0473)		(0.0526)
Neutral × $\Delta_{t,t-2}$Emissions (changes in percents)		-0.0908**		-0.0673*
		(0.0385)		(0.0364)
Green × $\Delta_{t,t-2}$Emissions (changes in percents)		-0.169**		-0.147***
		(0.0704)		(0.0489)
p-value: Brown × X = Green × X	0.050	0.042	0.890	0.370
Type FE	Yes	Yes	Yes	Yes
Year 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 differentially reacts to percentage changes in firm emissions depending on whether the firm is brown, netural, or green. The dependent variable in Columns (1) and (2) is the stock's overweight in green investment funds as defined in Table 6. The dependent variable in Columns (3) and (4) is the stock's MSCI KLD environmental rating as defined in Table 8. All columns include year fixed effects and indicators for whether the firm is brown, neutral, or green. *, **, 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

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 gases 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) 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 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 $\times$ 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 gases 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) 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 A3: Absolute change in total emissions by quintile

	Absolute changes in emissions		
	(1)	(2)	(3)
Quintile 2	-1.257***	-1.769***	-0.536***
	(0.0869)	(0.245)	(0.0620)
Quintile 3	-1.352***	-1.921***	-0.707***
	(0.0871)	(0.249)	(0.0638)
Quintile 4	-1.375***	-1.995***	-0.816***
	(0.0872)	(0.253)	(0.0661)
Quintile 5	-1.384***	-2.036***	-0.890***
	(0.0872)	(0.256)	(0.0676)
Year FE	Yes	Yes	No
Year × SIC2 FE	No	No	Yes
Value-weighted	No	Yes	No
Within SIC2 industry	No	No	Yes
N	24803	24786	24738
R^2	0.222	0.215	0.365

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 levels of scope 1 and scope 2 greenhouse gases emissions, where emissions is measured in million tons of CO_2 equivalents. 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) 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 A4: Interaction between interest coverage and performance

	Changes in emissions	
	(1)	(2)
Brown × ΔROA	-96.70**	
	(47.23)	
Neutral × ΔROA	11.02**	
	(4.768)	
Green × ΔROA	7.052	
	(6.720)	
Brown × Low interest coverage × ΔROA	-93.84	
	(83.21)	
Neutral × Low interest coverage × ΔROA	-7.842	
	(5.958)	
Green × Low interest coverage × ΔROA	5.787	
	(16.53)	
Brown × ΔIndustry ROA		-109.6
		(114.3)
Neutral × ΔIndustry ROA		51.93*
		(28.21)
Green × ΔIndustry ROA		178.1***
		(44.35)
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)
p-value: Brown × X × Z = Green × X × Z	0.241	0.019
Type × Low interest coverage	Yes	Yes
Type FE	Yes	Yes
Year FE	Yes	Yes
SIC2 industry FE	Yes	Yes
N	18779	19677
R^2	0.0434	0.0415

This table shows how the relation between firm emissions and performance depends on the firm's interest coverage. The dependent variable is $e_{t+1} - e_t$, the change in scope 1 and scope 2 greenhouse gases emissions, 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 type (brown, neutral, or green), indicators for low interest coverage in the previous year, and the firm or industry change in ROA. All columns include year fixed effects, indicators for whether the firm is brown, neutral, or green as well as interactions with the low interest coverage indicator, and SIC2 industry fixed effects. Below each regression, we report the p-value for the test of whether coefficients on the triple interaction term for brown firms and the triple interaction term for green firms are equal. *, **, and *** indicate significance at the 10%, 5%, and 1% levels, respectively. Standard errors are in parentheses and are clustered at the firm-level.

Table A5: Interaction between leverage and performance

	Changes in emissions	
	(1)	(2)
Brown × ΔROA	-6.108	
	(61.79)	
Neutral × ΔROA	7.548**	
	(3.373)	
Green × ΔROA	-0.851	
	(6.529)	
Brown × Firm leverage × ΔROA	-337.9**	
	(142.4)	
Neutral × Firm leverage × ΔROA	12.14	
	(13.51)	
Green × Firm leverage × ΔROA	46.10*	
	(24.92)	
Brown × ΔIndustry ROA		75.95
		(159.1)
Neutral × ΔIndustry ROA		41.57
		(28.80)
Green × ΔIndustry ROA		64.19*
		(33.60)
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	0.008	0.014
Type × Firm leverage	Yes	Yes
Type FE	Yes	Yes
Year FE	Yes	Yes
SIC2 industry FE	Yes	Yes
N	21765	24169
R^2	0.0445	0.0419

This table shows how the relation between firm emissions and performance depends on the firm's leverage. The dependent variable is $e_{t+1} - e_t$, the change in scope 1 and scope 2 greenhouse gases emissions, 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 type (brown, neutral, or green), the firm's leverage in the previous year, measured as debt-to-market ratio, and the firm or industry change in ROA. All columns include year fixed effects, indicators for whether the firm is brown, neutral, or green as well as interactions with leverage, and SIC2 industry fixed effects. Below each regression, we report the p-value for the test of whether coefficients on the triple interaction term for brown firms and the triple interaction term for green firms are equal. *, **, and *** indicate significance at the 10%, 5%, and 1% levels, respectively. Standard errors are in parentheses and are clustered at the firm-level.