MaRBLe Thesis

The impact of the dominant sustainable investment strategy on the environment

Abstract

The dominant sustainable investment strategy, defined as exclusionary screening, has rapidly expanded over the past decade. Recent studies, however, propose that this strategy can have a negative environmental impact if the increased cost of capital for Brown firms causes them to pollute more. I use a global sample of publicly traded companies from 2017 to 2022 to examine this claim. Applying Hartzmark and Shue's (2023) impact elasticity approach, I discover that Brown firms emit greenhouse gases at a rate that is more than 200 times higher than that of Green firms. Additionally, Brown firms have significantly more variation in emissions. There is a considerable negative correlation between short-term changes in emissions and historical stock returns for Brown firms, but not for Green firms. However, there is less clarity on the relationships with implied cost of capital, financial distress, and productivity shocks. Moreover, there is less evidence that Brown firms are currently rewarded for lowering emissions through sustainable funds or ESG ratings. Though the mixed results overall suggest a complicated link between cost of capital and emissions across global marketplaces, Brown firms often have greater potential to significantly change their impact on the environment. While this study cautions against extrapolating the results generated from US data, it also emphasises the ongoing need to assess sustainable investing strategies critically on a global scale.

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I. Introduction

The connection between financial markets and their impact on the environment has evolved to be a headline topic in a time of increased worldwide concern for environmental sustainability. The cornerstones of the current dominant sustainable investment strategy are the allocation of capital to businesses with a positive environmental impact and the divestment from those that are not in line with the Environmental, Social, and Governance (ESG) principles (Global Sustainable Investment Alliance, 2018). These methods are based on the idea that positive environmental change may be elicited by shifting financial resources away from so called "Brown" firms linked to business practises harmful to the environment and towards "Green" companies known for their dedication to sustainability. Although, this capital allocation process sounds reasonable in theory, in practice the effects yield different results. This counteracts the objective of sustainable investors in the pursuit of doing something good for the environment (European Commission, 2016).

In their paper, *Counterproductive sustainable investing: The impact elasticity of brown and green firms*, Hartzmark & Shue (2023) find that the described dominant sustainable investment strategy induces increased emissions contrary to popular held beliefs. To derive this conclusion, they examine the relationship between financing costs and environmental performance. For this, they introduce the concept of impact elasticity. This metric measures how sensitive a firm's environmental impact is to changes in its cost of capital. They investigate how financial returns, financial distress, and cost of capital affect emission changes, and differentiate between financial and productivity shocks. In addition, they explore the implications of incentive effects within the dominant sustainable investment strategy. Their analyses focus on a sample of American firms, which raises the question whether the disparity in impact elasticities of Brown and Green firms is also present in geographic markets with different characteristics.

Turning our attention to Europe for example, the investment landscape exhibits some subtle distinctions. Investors and firms not only face exposure to alternative social factors and political influences but also encounter differences in market specifics such as regulatory structures, investor preferences, and industry composition. The pronounced differences become more apparent when concentrating on sustainable investing, involving additional reporting requirements, varying levels of ambitions for emission reduction targets, and, more recently, the impact of carbon pricing.

ESG investments have attracted significant capital inflows in the last decade, with projections estimating them to constitute a third of the total global assets under management by 2025 (Bloomberg, 2022). This to some extent reflects investors' interests in balancing financial goals with environmental objectives and highlights their significance in the global financial environment. Climate change garnered significant attention from both the scientific community and policymakers due to its already manifest consequences. Given the urgency of addressing this ubiquitous phenomenon, the direction of large-scale capital investments becomes increasingly crucial. Therefore, the aim of this paper is to investigate the validity of Hartzmark and Shue's (2023) findings in a different market context by expanding observation to listed firms from all over the world. The goal is to extend the applicability of their analyses beyond the United States, emphasizing both similarities and differences in how firms from different geographic areas respond to shocks in their cost of capital, particularly regarding environmental considerations. Further, the objective is to build on existing research, including Pástor et al.'s (2021) conclusion that sustainable investing yields positive impact, Chava's (2014) findings outlining that firms with greater environmental concerns have a higher cost of equity, and Dyck et al.'s (2019) efforts to show the significance of sustainable investors' roles in facilitating a green transition.

I find that Brown firms have significantly greater emission levels and variability, suggesting a greater ability to meaningfully reduce their environmental impact compared to Green firms. This is in line with Hartzmark & Shue's (2023) claims. However, the impact elasticity evidence is more complex. For the sample at hand, I can only prove the hypothesized pattern with the historical financial returns as cost of capital proxy. The other cost of capital measures do not support a definite pattern. When combined, these results offer modest evidence in favour of the claims made by Hartzmark & Shue (2023) that Brown firms generally show significant negative impact elasticities. This sheds light on the diverging consequences based on country specific influences rather than an explicit cost of capital and emissions relation.

The paper is structured as follows. Section 2 focuses on the key insights from Hartzmark and Shue (2023) and other relevant literature for posing hypotheses in the analysis part. Sections 3 and 4 outline the data and methodology employed in the empirical research. Section 5 presents the results which are further compared with the results yielded by US firms in Section 6. The paper ends with Sections 7 and 8, which address limitations in and identify potential topics for further research as well as conclude the main takeaways.

II. Literature and Hypotheses Development

2.1 Relevance

Recent trends in asset management, particularly the decarbonization of institutional portfolios, highlight the need for sustainable financing alternatives and their increasing impact on investment portfolios. Institutional investors increasingly favour investments in Green over Brown firms, exhibiting herding behaviour towards decarbonization. Hedge funds and investment advisors, who are acknowledged as smart investors, are leading this trend and exhibit the increasing incorporation of environmental considerations into investment decision processes. This behaviour is in line with the financial market's adjustment to these developments as well as a larger cultural trend towards environmental consciousness and the fight against climate change (Benz et al., 2020).

Decarbonization is a critical step in ensuring portfolios are aligned with the future low-carbon climate economy, especially considering the substantial financial consequences of climate risks for institutional investors. Anticipations of regulatory changes and changing risk-return patterns in reaction to climate hazards contribute to this trend. Due to the growing popularity of sustainability ratings for investment goods and the social need for sustainability, institutional investors show signs of flocking towards sustainable projects and firms (Benz et al., 2020).

The predicted impact of the current greenhouse gas-emitting infrastructure to future emissions emphasises the necessity of such a shift. Rising sea levels and increasing global mean temperatures over the next decades are inevitable if present greenhouse gas concentrations continue at their current level. Over the next 50 years, it is anticipated that the existing infrastructure will contribute significantly to CO_2 emissions; therefore, extraordinary efforts are required to develop alternatives and overcome infrastructural inertia. This is in line with international climate goals, such as keeping global warming well below 2°C of pre-industrial levels and calls for a reorientation of capital flows towards more sustainable economic structures (Davis et al., 2010). In light of the urgent climate problem, the shift towards sustainable finance is not just a fashion.

2.2 Ambiguity in the observation of various proxies

Research on the empirical relationship between many financial indicators, including performance, cost of capital, and efficiency with environmental, social, and governance (ESG) aspects reveals a complex and sometimes contradictory landscape. Research has primarily shown a negative correlation between capital costs and sustainability performance, indicating that high ESG performance is generally regarded favourably by the market and lowers capital costs (Gianfrate et al., 2021). However, the results of this association vary greatly depending on the methodology and sustainability indicators employed, and they lack consistency across various studies or regions. For example, Gianfrate et al. (2021) suggest that environmental disclosure and cost of capital are negatively correlated, especially in firms with strong ESG performance. On the other hand, Atan et al. (2018) report that a firm's weighted average cost of capital and its overall ESG score are positively correlated.

Moreover, the empirical literature on cost of capital and sustainability primarily concentrates on developed markets, particularly the United States, leading to considerable diversity in the metrics employed. However, this literature tends to underrepresent emerging markets. This underscores the vital importance of considering the institutional and cultural framework in which businesses and investors operate. Furthermore, there has been disagreement over the relationship between ESG and financial performance. While some meta-studies have found positive correlations between ESG performance and stock performance, operational efficiencies, and lower cost of capital, others have found mixed results (Whelan et al., 2021). The challenges in ESG research, including inconsistent taxonomy, insufficient attention to material ESG issues, and conflicting ESG data, exacerbate these disparities even more (Whelan et al., 2021).

While there is a growing consensus on the importance of sustainable performance, empirical findings remain inconclusive, underscoring the necessity for further research to address these gaps and inconsistencies. This also emphasizes the importance of exercising caution when extrapolating findings.

2.3 The effect of sustainable investing

There is a noteworthy lack of clarity regarding how sustainable investing affects unsustainable firms' cost of capital. Blitz et al. (2020) suggest that although sustainable investing is rapidly expanding and asset managers and asset owners are pushing for a more sustainable global financial system (Principles for Responsible Investment, 2023), this change in investment strategies may not have a substantial impact on the flow of capital towards unsustainable firms. Unsustainable firms have not encountered significant obstacles when trying to secure finance, which suggests that over the examined time, sustainable investing has not really robbed these businesses of new money.

Simultaneously, the correlation between equity capital costs and carbon risk provides a more nuanced viewpoint. Kim et al. (2015) show a positive relation between the cost of equity capital and carbon intensity, which serves as a proxy for carbon risk. Companies with higher carbon intensity or inadequate carbon management may have to pay more for capital due to the global trend of stricter greenhouse gas emission rules (Kim et al., 2015). This link is consistent even in the absence of voluntary sustainability reporting, suggesting that disclosure policies have less of an impact on investor perceptions than actual carbon management practises (Kim et al., 2015).

The outcomes of these studies bear significant future implications. While the impact of sustainable investing on capital allocated to unsustainable firms remains uncertain at present, this scenario could evolve with shifts in regulatory landscapes and investor conduct. Investment choices may be influenced by the increasing importance of carbon risk management, especially as financial markets progressively integrate environmental factors into their valuation models. Therefore, notwithstanding the uncertainties that exist today, it is imperative to continue to explore and analyse the possible long-term consequences of carbon risk management and sustainable investing on capital flows and corporate behaviour.

2.4 Inefficiencies in sustainable investing

Green and Roth (2023) critically examine the effectiveness of values-aligned sustainable investing techniques. According to their theoretical paradigm, investor rivalry for socially valuable assets may lead to inefficiencies, potentially elevating investment costs and diminishing social effect. These strategies frequently lead to financial trade-offs without a corresponding increase in the number of socially beneficial projects, contrary to their goal of redirecting funds towards such initiatives. Rather than creating new societal value, this misalignment results in wealth transfers from investors to the current owners of the firms. In practice, values-aligned sustainable equity mutual funds have not substantially changed the proportion of profitable, high social-value companies within their portfolios. This raises questions about the effectiveness of these strategies in attaining the desired social impact.

These results suggest that the current carbon transition initiative may not be supported by the prevailing sustainable investment strategy. Hence, I derive the first hypothesis:

H1: The dominant sustainable investing movement provides weak incentives for Brown firms to become Greener.

Moreover, Hartzmark and Shue (2023) introduce the concept of impact elasticity to explore the effectiveness of sustainable investing strategies. They define it as the change in a company's environmental impact due to a change in its cost of capital. A crucial insight from their study is that sustainable investing, involving capital allocation to green companies while avoiding brown ones, may not be as successful as initially presumed. This stems from the fact that, unlike Green firms, which exhibit only modest improvements under similar circumstances, Brown firms display a more pronounced negative impact elasticity, meaning they tend to reduce their adverse environmental impact in response to easier access to capital.

This insight has significant implications for sustainable investing, suggesting that investors might be foregoing the opportunity for a more substantial environmental impact by solely focusing on green enterprises. Investing an equivalent amount in a Brown firm could lead to a notably higher reduction in emissions compared to investing the same amount in a Green firm. This is because Brown firms, often starting with higher emission levels, have greater flexibility to diminish their environmental impact in response to improved financial conditions. In contrast, environmentally sustainable firms, which typically operate at lower emission levels, may experience diminishing returns on additional investments in terms of environmental benefits. This calls for the investigation of the second hypothesis:

H2: Impact elasticity varies significantly between Green and Brown firms.

Therefore, to maximize the environmental benefits of sustainable capital allocation, a reassessment of investment strategies challenging conventional wisdom in sustainable investing may be necessary, as indicated by the research conducted by Hartzmark and Shue (2023) and Green and Roth (2023).

2.5 The counterproductive effect of sustainable investing

A firm’s financial wealth, or lack thereof, is another crucial factor that could influence its impact on the environment. In particular, Guérin and Suntheim (2021) shed light on the complex relationship between economic distress and environmental performance of companies in the COVID-19 crisis. Businesses, especially those with limited resources, generally perform worse in a stressed economy. Because financially constrained businesses tend to prioritize short-term financial survival over long-term environmental sustainability, this decline is primarily attributed to a reduction in green investments and potentially an increase in greenhouse gas emissions.

Considering this scenario in light of Hartzmark and Shue's (2023) research on sustainable investments adds a layer of complexity. According to their impact elasticity theory, the commonly adopted sustainable investing approach, diverting funds from firms with environmental risk, may inadvertently exacerbate the very environmental degradation it aims to prevent. Reducing financial support for Brown firms not only amplifies their adverse environmental impact, but also hinders their capacity to implement environmental improvements. This finding is particularly concerning, given that empirical evidence shows diminished environmental performance in financially constrained companies.

This highlights a significant oversight in the existing framework for sustainable investing. While the intention is to promote environmental sustainability, the actual impact may yield contrary consequences, exacerbating environmental strain instead of ameliorating it, especially within the context of economic downturns and financial distress. In light of these findings, I formulate the third hypothesis.

H3: The current sustainable investing strategy, which involves divesting from Brown firms and investing in Green firms, is counterproductive for environmental targets.

2.6 ESG ratings and the implications for sustainable investors

Sustainable investors often rely on independent ESG ratings for guidance. However, this approach has certain inefficiencies, primarily because these assessments tend to be overly optimistic. According to Bams and Van der Kroft's (2023) study, ESG ratings primarily hinge on anticipations of future enhancements rather than accurately representing a company's present sustainable performance. This mismatch leads to a frequent inverse relationship between ESG ratings and observable sustainable performance. Due to this phenomenon, capital has been allocated disproportionately, with investors favouring firms that have high ESG ratings, yet may perform poorly on sustainability criteria. Heeb et al. (2022) investigate investor behavior further and discover that investors' willingness-to-pay is dependent on relative impact levels rather than absolute impact levels when comparing sustainable projects. This potentially results in a misaligned asset allocation. The ESG rating system's emphasis on proportionate emission reductions, which naturally rewards Green firms with already low absolute emissions, is the source of this discrepancy. Conversely, Brown firms are disregarded because of their lower ESG ratings, even though they have a greater potential for large emission reductions. This bias unintentionally skews asset allocation away from the most sustainable alternatives, highlighting a fundamental problem in the ESG rating methodology and its impact on investment strategies.

Regulatory frameworks such as the Non-Financial Reporting Directive of the European Commission from 2017 have further exacerbated the issue by inflating ESG ratings without bringing about comparable improvements in sustainable practises. According to Bams and Van der Kroft (2023), these measures have been shown to lower the cost of funding for companies with inflated ESG scores, which encourages a focus on rating improvements rather than actual environmental impact. This leads me to establish the fourth hypothesis.

H4: ESG scores are a flawed indicator for the direct effect of environmental measures.

Furthermore, Benz et. al (2020) reveal in their study on sustainable trends in asset management that institutional investors tend to favour green investments due to peer behaviors and trends. They also find that the actual impact of their investment targets is often different. This herd mentality results in an overrepresentation of green companies in portfolios, revealing a disparity between investment decisions and the substantial environmental effects these choices aim to mitigate. Therefore, I include hypothesis five as a final aspect to investigate.

H5: Investors are willing to pay unrelated to the magnitude of impact, leading to an overweight of Green firms in their portfolios.

Heinkel and Zechner (2001) provide theoretical evidence that green investors steer clear of polluting, low ESG companies due to exclusionary screening. Because there is no risk sharing, high emitting firms have a higher cost of capital, which may encourage them to change their ways and become more sustainable. However, unintentional repercussions could result from the greater cost of capital, if it discourages new players from entering polluting but necessary industries (Heinkel & Zechner, 2001). This is a prominent aspect highlighting the complexities of finding the right way to facilitate a green transition without harming the environment in the short to medium term.

2.7 Contribution

Having established the significance of examining the connection between a firm's emissions and cost of capital in light of existing literature, another aspect to consider is the context in which this investigation is conducted. Hartzmark and Shue (2023) support their hypotheses using data from companies listed in the United States. Nevertheless, it remains unexplored whether their findings are also applicable in a global context.

Research by Gatzert and Reichel (2022) on the insurance markets in the United States and Europe emphasizes how different regulatory and cultural environments affect sustainable investing strategies. Furthermore, Fairchild's (2008) analysis of the industrial sector shows that cultural aspects and industry-specific factors influence environmental strategies. These results highlight the importance of taking into account a range of regulatory, legislative, and cultural contexts, as does Boffo and Patalano's (2020) thorough research of global environmental policies and market responses. A broader view is essential for a more profound understanding of the relationship between emissions and cost of capital in the international context, to potentially be able to mitigate the environmentally harmful effects of the current dominant sustainable investment strategy.

III. Data

I conduct the empirical study on a historical dataset of stock listed firms worldwide, covering the period from 2017 to 2022. The specific country coverage is described in appendix table A1. The availability of ESG information from Refinitiv ESG together with the required structural characteristics for panel data limits the choice of selected firms. To gather their environmental impact, I use scope 1 and scope 2 greenhouse gas emissions as a metric accessed through the Refinitiv ESG database. Scope 3 emissions data is not as well reported and therefore difficult to include while still maintaining a comprehensive data sample. Scope 1 and scope 2 emissions encompass the direct emissions from the firm's equipment and the indirect emissions acquired through, for example, the purchase of energy, respectively. Greenhouse gas emissions are measured in millions of CO_2 equivalent tons. To adjust for firm size, I calculate the firm emission intensity, which is reflected by firm scope 1 and 2 emissions divided by the revenue in million dollars. The analysis excludes scope 3 emissions, as they encompass all upstream and downstream emissions and typically introduce significant noise.

Additionally, to examine variations between firms emitting more and less, I categorize the sample firms into quintiles. I designate color labels, identifying the highest-emitting quintiles as brown firms, the lowest emitters as green, and those in between as neutral. Similarly, I cluster the firms by their SIC2 industry classifications.

I retrieve accounting data from the Compustat Global database, including the real and financial performance, leverage, earnings, and revenue of the firms examined. I evaluate firm performance both at the firm level, using individual firm data, and on the industry level. I establish the latter by first calculating the overall value-weighted industry performance. Afterwards, I subtract the value-weighted industry return of the focal firm from its respective industry returns.

A key component in my study is the cost of capital. In the base case, I consider simple historical returns. As recommended by Hartzmark and Shue (2023) and following Bams and Van der Kroft (2023), I afterwards consider a set of alternative approaches for the implied cost of capital. I use the approaches suggested by Gebhardt et al. (2001), Hou et al. (2012), Chattopadhyay et al. (2022), and Fama and French (2015, 2017). The alternative methods for calculating the implied cost of capital (ICC) including earnings per share and stock price data I gather from the Center for Research on Stock Prices (CRSP), as well as financial statement data including book value of equity, earnings, dividend, and long-term debt figures from Compustat Global. Since the proposed methods for calculating the cost of capital all have their advantages and disadvantages, I further employ a composite ICC estimation which takes the simple average of the four methods.

For the investigation of the incentive effect through sustainable funds, I consider the overweight of sustainable fund holdings compared to the market portfolio. I evaluate the portfolio allocations of institutional investors committed to social responsibility by utilizing Thomson Reuters 13F holdings data. This data provides the percentage of the firm held by sustainable institutional investors following the UN Principles for Responsible Investment. The market portfolio is determined based on the value-weighted market share derived from the CRSP database.

3.1 Summary statistics

Table 1 shows that the data sample exhibits significant variability in scope 1 and 2 emissions, as evidenced by the standard deviation (SD) of around 18.9 million tons of CO_2 for a mean of just over 3 million tons. The median of 0.1 million of CO_2 in contrast implies that the emissions data is heavily skewed to the left. The emission intensity, which is derived from the total scope 1 and 2 emissions scaled by million dollars of revenue, has a mean of 391.9 and standard deviation of 1,315.6 tons of CO_2 per million dollars of revenue. To take a closer look at the data, I sort the firms into quintiles according to their emission intensity. Referring to Table 2, it appears that the average emission intensity range between quintiles as slightly decreased over time. This reduction mainly stems from the 20% of the sample of very high emitting firms with emission intensities above 1500 tons of CO_2 equivalents per year. The 20% of very low emitting firms with an average emission intensity of > 3 tons of CO_2 equivalents per year do not exhibit any significant trend over the horizon of the data sample.

The firm-level annualized returns have a mean of 12.28% with significant variability (SD = 54.11%). The industry returns have a slightly higher average of 14.55% and a similar degree of fluctuation (SD = 30.04%), compared to firm-level returns.

With an average annual change of -0.84%, the implied cost of capital of a firm indicates a notable shift across firms. Similarly, with a mean of -0.47%, the annual industry ICC movements exhibit a more mediated change on average, highlighting an elastic firm cost of capital. Examining the composite ICC, the average variation is likewise substantial at -0.78%. The industry-level composite ICC change, which stands at -0.14%, suggests that the cost of capital is variable at a firm-level, but relatively inelastic when considering the cost of capital of a whole industry as the measure averages out firm-specific variation.

IV. Methodology

In this upcoming section, I detail the methods used to apply the findings of Hartzmark and Shue (2023). All subsequent analyses rely on their impact elasticity framework, which they define as the change in a firm's environmental impact resulting from a shift in the cost of capital.

4.1 Impact variability

I first investigate the variability in firm emissions. The fluctuation of firm emissions on a year-to-year basis is an indicator for a firm’s ability to significantly change its impact on the environment. For that, I segment the data sample into quintiles based on their emission intensity. Based on the segmentation, I identify Green firms, the top quintile, Neutral firms, the three middle quintiles, and Brown firms, the bottom quintile. These are converted into indicator variables for later analyses to identify the firm type based on emission intensity. The indicators serve as control variables to measure differences between the firm types, i.e. whether the firms are Green or Brown. Further, I test for a significant difference in the annual absolute level change in emission intensity between quintiles by employing an ordinary least squares regression, stated in Equation 1:

$$\Delta E_{i,t+1} = \beta_0 + \beta_1 Quint2_{it} + \beta_2 Quint3_{it} + \beta_3 Quint4_{it} + \beta_4 Quint5_{it} + \varepsilon_{it} \qquad (1)$$

In the equation $\Delta E_{i,t+1}$ represents the absolute change $E_{i,t+1} - E_{i,t}$ in scope 1 and 2 greenhouse gas emissions of firm *i* measured in tons of CO_2 emitted per million dollars of revenue for fiscal year *t*. Further, $Quint[N]_{it}$ denotes a dummy variable indicating firm *i*'s quintile allocation. In addition, I will consider specifications with year fixed effects and type fixed effects. I do not include industry fixed effects due to complete collinearity when controlling for SIC2 industries.

Taking the first quintile as a baseline, I investigate disparities in the behavior of emission levels in three variations. First, I only control for the fiscal year effect, then I weigh the datapoints according to their CRSP market capitalizations to forego any anomalies caused by firms with little output and a disproportional baseline of greenhouse gas emissions. Third, I account for differences within industries by sorting the firms according to their previous-year emission ranks within their respective industries.

4.2 Impact elasticity

The impact elasticity framework laid out by Hartzmark and Shue (2023) measures a firm's sensitivity to changes in its cost of capital. I conduct regressions centered around a basic specification, which is outlined in Equation 2, and investigate different variations. The dependent variable is the annual change in emission intensity denoted with $\Delta E_{i,t+1}$. Further, the explanatory variables are the firm Cost of Capital, CoC_{it}, the value-weighted industry cost of capital, $IndustryCoC_{it}$, and a vector X_{it} that includes a set of control variables added throughout the analysis.

$$\Delta E_{i,t+1} = \beta_0 + \beta_1 CoC_{it} + \beta_2 IndustryCoC_{it} + \beta_3 X_{it} + \varepsilon_{it} \qquad (2)$$

First, I turn towards the explicit effects caused by financial shocks reflected by the impact elasticity. I start by looking at the relationship between shifts in emissions and shifts in the performance of the company, which acts as a proxy for the cost of capital. A positive performance shock will likely make it easier for the company to get funding. In a similar manner, a poor performance shock should raise the firm's shadow cost of capital. As an indicator for firm performance, I take the firm's stock returns. Further, I introduce the firm color dummies derived from the quintiles as control variables in vector X_{it} for a firm being Green, Brown or Neutral. I regress the absolute change in emissions on firm returns and the value-weighted industry returns, for which I exclude the focal firm, separately. The latter controls for the potential problem of reverse causality, i.e. being green somehow causes firms to perform better, and omitted variable bias, i.e. other external factors causing a transition towards green practices. Firm-specific decisions are anticipated to impact only firm returns, whereas shocks to industry performance manifest in both the overall industry and individual firm performance.

I repeat this analysis with the long run change in emissions, since I assume firm emissions vary. It is likely for firms to require a certain adaptation period until the effects of their environmental sustainability efforts become visible. Hence, I determine how financial performance affects four-year emission changes. For that, I regress the change in emissions intensity in over the period $[t, t+4]$ against the financial returns in year *t-1*, which act as a proxy for the cost of capital. Acknowledging the impact of industry dynamics on specific firm behaviors and to circumvent omitted variable bias, I further explore the significance of industry-level annual returns. For both cases, I also include a variation regressing a low industry returns indicator, meaning the respective firm ranking in the bottom decile of the sample. I also make sure to control for potential confounding variables in my model by incorporating fixed effects for firm type and year fixed effects.

4.3 Financial distress

The dominant sustainable investment strategy focuses on depriving brown firms of capital and thereby increasing their cost of capital. It is reasonable to argue that in the case of financial distress firms are less likely to choose green projects over brown ones. The former tend to require major upfront investments with back-loaded cash flows, whereas the latter mainly entail stable low commitments and front-loaded cash flows (Hartzmark & Shue, 2023). I further investigate this assumption by measuring the impact of financial distress on environmental performance.

Since financial distress brings about many implications, I measure it in four ways as suggested by Hartzmark and Shue (2023). These include the ability to pay interest payments on existing debt, the Altman Z-score, and the overall rank for financial and industry performance within the sample. The ability of interest payments is expressed by an indicator that takes on the value one, if the firm exhibits an interest coverage ratio in the bottom decile of the sample. The Altman Z-score is a common predictor for a firm's probability to go bankrupt. It is also included through a distress indicator, which is equal to one if the firm has a score within the bottom decile of the sample. Further, the financial firm-level and value-weighted industry-level performance are established in the same manner, through a dummy variable that is one if the firm is in the respective bottom decile. In all of these regressions, I control for the firm color to investigate if there is a difference between Brown and Green firms, the respective fiscal year, and the industry the firm operates in.

4.4 Isolating the financial channel

Further, to examine the uninterrupted results of the environmental impact of a change in firm performance and further cost of capital, I attempt to isolate the financial channel in three ways. I compare the effects of the implied cost of capital, investigate the effect of real industry shocks on leveraged firms, and turn towards exogenous variations mimicked by demand for dividend payments.

First, as a complement to the previous tests, I directly investigate the implied cost of capital (ICC) instead of the previous proxy, firm performance. The ICC investigation only holds a supplementary role. This is because the calculation results greatly reflect the valuation model used. Hence there is no single, objective ICC. For that reason, I also employ a composite ICC, which is calculated by taking the equally weighted average of four different ICCs, namely derived from using the methods of Gebhardt et al. (2001), Hou et al. (2012), Chattopadhyay et al. (2022), and Fama and French (2015, 2017). To estimate the effect of changes in the implied cost of capital, I regress the annual absolute change in emission intensity on the change in the Fama and French (2015, 2017) ICC and composite ICC. Again, I control for the firm type and include time fixed effects.

As already mentioned previously, I want to ensure that the regression results are not driven by reverse causality or other biases. Hence, I also include regressions with the value-weighted industry Fama and French (2015, 2017) ICC and composite ICC against the change in emission intensity to ensure the validity of the resulting implications. Again, the reason is that an industry shock would strongly affect all firms, whereas a firm-specific shock only influences the cost of capital of that specific firm.

Continuing, a prevalent hypothesis is that already leveraged firms react more heavily to overall industry shocks indicated by the change in industry return on assets (ROA). To examine this phenomenon on the sample data, I regress the emission change against interaction terms between the change in industry ROA, an indicator for interest coverage, and, the firm's debt-to-value ratio, a measure for firm leverage. Again, the interest coverage indicator takes on the value one, if the interest coverage ratio of the firm is within the bottom decile of the sample. I employ two regression variations to investigate interest coverage and firm leverage effects separately.

Subsequently, I explore how a firm's emissions and investor demand for dividend payments relate, with a special emphasis on the "free dividend fallacy". This fallacy, which has its roots in behavioral finance, states that a large portion of investors view dividends as separate, nearly "free" returns from the overall stock price. The central theory posits that firms might undergo shocks in their cost of capital due to shifts in dividend distributions triggered by this behavioral bias.

I use a proxy to assess this, following Hartzmark and Solomon (2013). Using the value-weighted interim return over all dividend payment events in a given year, I calculate dividend demand annually. In order to determine whether dividend demand is higher than the median during the sample period, I track it both continuously and by using an indicator. Thereby I take advantage of the special dynamics that occur between the dividend announcement, when all relevant information for the dividend payment is shared, and the ex-dividend date. There should be no abnormal gains during this transitional period since it contains no new information. Any gains hence are mostly attributable to investors buying the stock to take part in the expected dividend payout.

I run two regressions. In the first, I examine the indicator for firms with dividend yields above the median interacting with the value-weighted interim returns as a dividend demand proxy. In the second, I also include the indicator for firms with dividend yields above the median and add the interaction with a high dividend yield indicator, which is equal to one when the interim returns are above the median.

4.5 Incentive effect

The statistical analysis techniques I have outlined so far concentrate on the immediate impacts that alterations in the cost of capital have on the greenhouse gas emission intensity of the respective sample firms. Next, I extend my perspective to the potential implications of an indirect incentive effect on Brown firms. This impact involves the compensation of brown firms when they demonstrate initiatives to transition to greener practices. One manifestation of this is seen through sustainable investors expressing interest in holding equity stakes in these firms, consequently enhancing their access to capital and reducing costs.

Hence, I investigate the relationship between changes in emission intensity and the holdings of UN PRI signatories[1]. To accomplish this, I quantify the extent to which firms are overrepresented in sustainable funds adhering to the Principles of Responsible Investment (PRI) guidelines relative to the weight of their listed equity in a value-weighted CRSP market portfolio. Currently, the overrepresentation in green funds serves as the dependent variable in the regression model. In Equation 3, I use the firm's emissions level as a baseline in the regression analyses and add the shift in emissions, both in terms of percentages and levels separately, that occurred a year prior:

$$Overweight_{it} = \beta_0 + \beta_1 Emissions_{it} + \beta_2 \Delta_{t,t-x} Emissions(level)_i + \beta_3 \Delta_{t,t-x} Emissions(percent)_i + \beta_4 X_{it} + \varepsilon_{it} \quad (3)$$

where $Overweight_{it}$ is calculated as the stock's relative weight in sustainable funds compared to its weight in the market portfolio. $\Delta_{t,t-x} Emissions(level)_i$ as well as $\Delta_{t,t-x} Emissions(percent)_i$ specify different measures for the change in emissions over the period duration $[t-x, t]$, X_{it} is a vector of control variables. I also include year fixed effects. Next, I repeat the same analysis and incorporate the two-year lag in emissions to account for short-term stickiness.

Another way to reward firms that are actively becoming greener is by giving them a better ESG rating. In order to examine if and how firms are rewarded for becoming greener, I regress their Refinitiv ESG rating given as ESG_{it} for firm *i* in year *t* on the one- and two-year changes in levels and percent, as illustrated in Equation 4. Again, I control for the year fixed effects with and include control variables.

[1] PRI signatories pledge to address nine priority areas relating to ESG matter and other tangent areas with their capital. The PRI initiative aims to support the investors improve alignment throughout the investment chain and guide them in their hunt of long-term value.

$$ESG_{it} = \beta_0 + \beta_1 Emissions_{it} + \beta_2 \Delta_{t,t-x} Emissions(level)_i + \beta_3 \Delta_{t,t-x} Emissions(percent)_i + \beta_4 X_{it} + \varepsilon_{it} \tag{4}$$

Lastly, I delve into the specificities of how percentage changes in firm emissions, contingent upon whether the firm is categorized as Brown, Neutral, or Green, influence the reward in the cost of capital through sustainable investing. To analyze this, I construct distinct regression models with the environmental score and the overrepresentation in green funds as the dependent variables. Once again, I use the firm's emissions level as a reference point. I introduce interaction variables between the firm type label (Brown, Neutral, and Green) and the one-year period to capture the effects based on the firm's color. I replicate this analysis using the two-year lagged percentage changes in emissions to accommodate short-term inertia. Furthermore, I incorporate controls for the firm type label and include time fixed effect and type fixed effects.

V. Results

The following section includes five parts. First, I show that Brown firms exhibit a greater emissions variability than Green firms. Second, I take on the divergence of the effect on their emissions to shocks to the cost of capital proxied by historical stock returns. Thereafter I introduce financial distress as an additional factor. Further, I find that the initial pattern discovered with financial returns is not as prominent when taking the implied cost of capital or looking at productivity shocks. I show that although there seems to be a pattern for some, there is not necessarily a significant differentiating factor for Green and Brown firms in all cases. Finally, I discuss the incentive effect through ESG ratings and firm overweight in funds of investors pledged to the PRI guidelines.

5.1 Emissions variability and quintiles

The underlying assumption of the impact elasticity framework defined by Hartzmark and Shue (2023) is that the emissions variability of Brown firms is significantly larger than the variability of Green firms. Emissions variability is a vital consideration as it is an indicator of how much a firm can change its level of emission in a reasonable timeframe (Hartzmark & Shue, 2023). I segment the firms of the data sample into quintiles per fiscal year according to their level of combined scope 1 and scope 2 emissions. As illustrated in Figure 1 in the left panel, I find that the total emissions of the highest emitting firms, classified as Brown, exhibit a much larger magnitude compared to the low emitters, the Green firms. This could arise from differences in firm sizes. However, also when scaling the raw emissions by firm revenues in the panel on the right, the trend of Brown firms having a much higher emissions intensity prevails.

This insight highlights the importance of examining the absolute variability in firm emissions as Brown firms emit around 200 times more CO_2 per million dollars of revenue than Green firms do. To further illustrate this, a 10% change in a Green firm with an average emissions intensity of 8.3 tons of CO_2 amounts to 0.8 tons of CO_2 and is rather insignificant compared to a 10% change of a Brown firm (M = 1613.6 tons of CO_2) amounting to 161.4 tons of CO_2. Further, I find that Neutral firms, those allocated to the emission quintiles 2-4, also show a relatively small emission intensity compared to Brown firms. Hence, I expect Neutral firms to be closer in behavior to Green firms in the following analyses. Given the substantial differences, from here on out I only focus on the absolute level change of the firms' scope 1 and scope 2 emissions scaled by their revenues. Also, from this point onwards, I refer to emission intensity as emissions for simplicity.[2]

In Table 3, I regress the absolute year-on-year change of emissions on indicators for the firm quintile dummies according to their emissions. The omitted category is Quintile 1, representing the Brown firms. In column 1, I introduce year fixed effects to control for time in order to directly compare differences in emissions variability. I find that Green firms exhibit a smaller variability of 113 tons of CO_2 per unit of output[3] compared to their Brown counterparts. This is also supported by the bar chart in Figure 2 representing firm emission over emission quintiles, in contrast to the raw scope 1 and scope 2 emission quintiles in Figure 1. It is evident that the Brown firms' emissions rapidly decline from Quintile 1 to Quintile 2 and then exhibit a rather stable decrease with Green firms demonstrating around a fourth of the emissions of the Quintile 2 firms.

A valid concern is the potential of outliers arising from the calculation of emission intensity. Assuming that most firms have a baseline of emissions, firms with smaller revenues would exhibit disproportionately higher emission intensities than large firms. To account for the possibility of this bias, in column 2 of Table 3 I weight the observations by their fractional market shares within each respective SIC2 industry. Again, I find that the emissions of Green

[2] Unscaled total scope 1 and scope 2 emissions are referred to as raw emissions.
[3] Unit of output is used for brevity and refers to 1 million dollars of annual revenue.

firms is smaller by 189 tons of CO_2 per unit of output in contrast to Brown firms. This confirms that the differences in variability between Green and Brown firms is not an effect of small outlier firms.

In column 3, I further regress the absolute change in emissions on industry quintiles allotted by year and SIC2 industry. By that I explore whether the previously discussed pattern is also valid when controlling for the fact that some industries produce higher baseline emissions by nature than others. Once more, I find that there is a significant difference in emissions variability between Green and Brown firms.

In Figure 2, I demonstrate that the significant difference found between Green and Brown firms across the three specifications only holds if examining absolute level changes in emissions (top panels). In case of absolute percentage changes as in the bottom panels, this pattern completely disappears. The overall percentage change for all firms appears promising, however when quantifying in absolute terms with regard to the effect on the environment, Brown firms indicate a much greater potential for significant impact.

5.2 Impact elasticity with financial returns

Next, I estimate the impact elasticity for the data sample at hand. I use financial returns as a proxy for cost of equity and show that the impact elasticity of Brown firms is significantly positive and different to the impact elasticity of Green firms. Following Gordon and Gould (1978), it is well acknowledged in theory and practice that the yield at which a firm's stock is selling is a reasonable proxy for the cost of equity capital. Thus, firm equity returns are a fitting initial measurement. I expect the impact elasticity of Green firms to be around zero, as in the graphs of Figure 2, I find that their average variability is quite low or rather close to zero in comparison to Brown firms.

In Table 4 column 1, I regress the absolute year-on-year change of emissions on interaction terms of firm previous year annual returns and an indicator of whether the firm is Brown, Neutral, or Green. For Brown firms, I find a significantly positive impact elasticity of -0.37. This implies that with a one percentage point increase in a Brown firm's equity returns, the absolute level change of emissions would decrease by 0.37 tons of CO_2 per unit of output. The relation also holds symmetrically for a positive shock to financial returns. A one percentage point decrease in a Brown firm's financial returns would lead to an increase of emissions of the size of the impact elasticity. This suggests that if Brown firms are denied capital, they tend to become even more brown as a result. The coefficients of Neutral and Green firms are insignificant. However, with a simple F-test, I establish that the impact elasticities of Brown and Green firms are inherently different (p-value = 0.045).

When only regarding firm-level returns there are limitations such as the possibility for reverse causality and omitted variables. Hence, in Table 4 column 2, I repeat the regression on the absolute year-on-year change of emissions from year *t* with interaction terms of industry returns from *t-1* and firm type indicators. Following Hartzmark and Shue's (2023) intuition, industry returns should have an effect on firm-level equity performance, while firm-level choices regarding emissions should not implicate industry-level returns. Therefore, I take industry returns calculated by excluding the focal firm in order to forgo any bias through firm-specific variation. I find that the impact elasticity in this specific case is ambiguous. As expected, the F-test between the Brown and Green industry return interactions also does not yield a clear distinction.

However, the previous analyses fail to acknowledge that there might occur short-term stickiness in raw emissions that arises from short-term growth or decline of operations following a shock to the cost of capital. If this were the case, then the previously identified pattern would not hold over a long-term horizon. Therefore, aside from investigating the absolute year-on-year change in emissions I also look at the four-year change in emissions alongside the previous-year firm returns.

In Table 5, I regress the absolute four-year change in emissions on interaction terms between the lagged firm-level or industry-level returns and an indicator for whether the firm is Brown, Neutral, or Green. I control for year fixed effects. Against the expectations formed based on Hartzmark and Shue's (2023) findings, the impact elasticities I find in the analyses for changes in emissions over four years are inconclusive. Intuition suggests that the long-run changes should be even more pronounced than the short-run effects, i.e. that a decrease in financial returns leads to an even larger increase in emissions. If a firm makes an investment choice given its financial situation, then it likely takes an adjustment period for the full effect to come into force. However, the results I find throughout four different specifications on firm-level and industry-level as well as with low return indicators are insignificant and do not follow the same signage patterns as with the one-year horizon. Since the regular business cycle lasts between 3-5 years, it is arguable that for the case at hand a longer time horizon would be more beneficial (PWC, 2017). All in all, the four-year changes appear less informative than the short-term firm reactions.

5.3 Impact elasticity considering financial distress

Next, I further examine the impact of financial distress as proxied by common indicators such as the Altman Z-score, the interest coverage ratio, and overall low financial returns on firm and industry-level in a sample comparison. Such indicators are simplified predictors for the probability of default of a given firm and can also hint to a firm's liquidity situation. The assumption is that firms that already show signs of financial distress react more heavily to shocks of cost of capital by increasing their emission levels (Hartzmark & Shue, 2023). They typically already face high discount rates, so the ease provided by becoming more sustainable and reducing carbon risk should appear as a promising opportunity (Kim, An, & Kim, 2015). On the other hand, a firm in distress will want to generate as much cash inflows as possible while minimizing the magnitude of necessary investments. As highlighted by Polman and Winston (2022), most green investments take time to pay off and especially in the matter of sustainable investing, decision-makers tend to opt for the cheaper, quick cash flow generating version at present, while not considering the whole picture. The expectation is for Brown firms to have a greater increase in emissions when distressed than a Green distressed firm, given their larger variability in emissions.

In Table 6, I regress the absolute year-on-year change of emissions on interaction terms of the firm type and the three previously mentioned indicators. First, the Altman Z-score is a numerical indicator that stems from ratio analysis and derives the probability of a firm's bankruptcy within the next two years based on a credit rating system (Altman, 1968). Second, the interest coverage ratio, which is computed by taking the EBITDA over the interest expense and used as it is common practice for creditors to require borrowing firms to maintain a certain interest coverage ratio (Dothan, 2006). A low interest coverage ratio increases the likelihood of not being able to raise new debt capital and ensues capital constraints that potentially lead to financial distress. Lastly, I also introduce a low returns indicator, since financial returns dictate the cost of equity (Gallo, 2015). I look at firm level returns and value-weighted industry returns excluding the focal firm in order to circumvent the possibility for omitted variable bias, i.e. firm specific noise, and reverse causality. All of these markers indicate in the regressions if the respective firm is within the bottom decile of the sample with regard to the financial distress variable.

Contradictory to the logic introduced, I find that the financial distress indicators in the interaction terms are largely uninformative for a linear relation. The coefficients are the same across all four specifications and are only significant at the 10% level for the Neutral interaction terms. This implies that the individual distress markers hold little explanatory power and that the fixed effects included are likely responsible for the significance. Given the ambiguous result, I cannot state that distressed firms exhibit different reactions to shocks given that they are Brown or Green.

5.4 Isolating the financial channel

After having examined financial returns and distress markers as general proxies for shocks to the cost of capital, I dive deeper on the effects solely occurring through the financial channel. To exclude the additional impact of changes in productivity, I first estimate the impact elasticity through the implied cost of capital measure. The implied cost of capital refers to the internal rate of return of a firm's market value equated to theoretic firm value calculated by a valuation model, such as the residual income model (Echterling, Eierle, & Ketterer, 2015). Then, conversely, I investigate firm reactions to productivity shocks specifically under consideration of leverage. Finally, I relate the results from an exogenous variation proxy to arrive at robust results.

5.4.1 Impact elasticity with implied cost of capital

The ICC literature is characterized by a large number of alternative techniques and overall the body of research supporting ICC models is still quite young. Moreover, ICC estimations that are empirically determined vary based on the technique used and the most effective ICC strategy is still a matter of debate (Echterling, Eierle, & Ketterer, 2015). For that reason, I employ not only a single ICC, but also make use of a simple average that equally-weights four different methods proposed by Gebhardt et al. (2001), Hou et al. (2012), Chattopadhyay et al. (2022), and Fama and French (2015, 2017).

In Table 7, I regress the absolute year-on-year change of emissions on interaction terms of the firm type (i.e. Brown, Neutral, or Green) and the absolute year-on-year change of the ICC as well as composite ICC, the simple average of the four ICC calculation methods described above. I do that on a firm-level and value-weighted industry-level basis excluding the focal firm in order to account for the possibility of reverse causality and omitted variable bias through firm specific variation.

For the first two specifications using only the ICC derived according to Fama and French (2015, 2017), I find that Green and Neutral firms have a positive and smaller impact elasticities than Brown firms. Concurrently, Brown firms in the sample have an average reverse impact elasticity[4] of 5 and 13 tons of CO_2 equivalents per unit of output on the firm and industry-level respectively. This means that Brown firms again follow the previously identified pattern of increasing their emissions by about an average Green firm' s total emissions given a change in ICC of one percentage point. Again, I confirm the difference in sensitivity through a simple F-test. I identify a similar pattern also in the composite ICC industry-level specification, although I cannot establish a significant difference between Green and Brown firms. In addition, the firm-level composite ICC results do not indicate a straightforward relation, which could be due to the fact that there are contradicting trends within the same industry that are rescinded when controlled for by taking the value-weighted industry average.

5.4.2 Impact elasticity considering productivity shocks

To investigate productivity shocks and the leverage effect, I use the value-weighted industry return on assets of the previous year excluding the respective focal firm. As per Dinlersoz et al. (2019), sectors with a higher fraction of highly leveraged firms contract greater during crises. Firms with high levels of debt shrink more with regard to revenue and employment, in other terms productivity, than barely leveraged ones. This fact also applies to industries that present high average firm leverage values as a whole, in that they contract more during economic downturns than compared to the rest (Dinlersoz et al., 2019).

In Table 8, I regress the absolute year-on-year change of emissions on interaction terms of the firm type, the year-on-year change of the industry ROA excluding the focal firm, and the interest coverage indicator or the firm leverage ratio respectively. Also, I include the interactions of firm type and the change in industry ROA as controls.

I obtain results that indicate the presence of a separate negative financial distress effect next to the financial performance effect. While the results for the low interest coverage indicator are ambiguous, which I expected given the previous investigation, the effect of firm leverage is relatively pronounced. Brown firms that are levered exhibit a three times greater emissions variability in absolute terms compared to the scenario that does not account for leverage. For regular Brown firms, a decrease in industry ROA leads to an increase in emissions, as presumably firms have to cut back on their investments and green projects are among the first to be targeted. If they are levered, however, the coefficient implies that a downturn in industry ROA could result in a decrease of emissions. A possible explanation here

[4] Reverse impact elasticity here, since the increase of emissions caused by the increase in implied cost of capital leads to a negative impact on the environment. So, although the coefficient is technically positive, Brown firms still exhibit a negative impact elasticity.

could be the greater likelihood of bankruptcy of distressed firms resulting in the cessation of operations.

5.4.3 Impact elasticity considering exogenous variation.

The content of this subsection is not derived from the empirical analysis as the other parts are but outlines the findings Hartzmark and Shue (2023) derived in their investigation of US firms. In prior work, Hartzmark and Solomon (2013, 2019) introduce abnormal returns effects caused by the free dividend fallacy and explain how they influence share prices. This phenomenon is a useful factor of share price variation that is not directly connected to the spheres of sustainable investing. This context helps to validate that Brown firms exhibit a greater emissions variability than Green firms regardless of the variable influencing the cost of capital.

Hartzmark and Shue (2023) regress the absolute year-on-year change of emissions on interactions of the firm type, a high dividend yield indicator, and dividend demand factors. The former represents an indicator whether the firm has a dividend yield which is above the sample median. The latter compromises the value-weighted interim return in percent in the period after the dividend announcement and the ex-dividend date combined from all distributions throughout the year. In theory this period in between does not provide any additional economically valuable information with regard to returns and hence mainly reflects the increased demand through dividend-seeking investors (Hartzmark & Solomon, 2013). The results from Hartzmark and Shue's (2023) regression analysis indicate that the differentiated pattern of Brown and Green firms prevails, regardless if the shock to the cost of capital comes from an exogenous source. They find that Brown firms significantly reduce their emissions resulting from the lower cost of capital through the dividend demand and that Green and Neutral firms do not react as greatly.

5.5 Incentive effect

Up until now, I predominantly find that the dominant sustainable investment strategy leads Brown firms to increase their emissions as they are starved of capital. Yet, equivalently one could assume that if Brown firms were to make efforts in reducing their emissions, they would benefit by a decreased cost of capital facilitated by a higher ESG score, decreased environmental risk, and lower cost of equity (Dalò et al., 2023; Albuquerque et al., 2014). In practice, ESG scores however are driven by relative emission reductions, the percentage change in emissions rather than the absolute value of CO_2 that is saved (Martis, 2021). Further, sustainable investors invest in stocks labeled as “green” based on these ESG scores and hence tilt their portfolios towards firms that promise, though not necessarily realize the sustainability efforts (Bams & van der Kroft, 2023). Increasing the effect, imitators follow these green investors in hopes of abnormal returns (Benz et al., 2020).

In Table 9, I employ the overweight that Green firms have in UN PRI signatories' portfolios compared to the CRSP market values as dependent variable. As explanatory variables I use four variations of changes in emissions: in absolute and percentage changes as well as one and two-year changes. Unexpectedly, I find that the coefficients are not statistically meaningful, although the overweight appears larger for the reported coefficients when looking at the percentage changes.

In Table 10, I examine the influence of emission changes on the Refinitiv ESG score. I regress the numerical score as the dependent variable again on the four variations that measure emission changes. As a result, I attain that percentage changes do not have a real, significant effect on the firms' ESG scores. At a 20% significance level, I also obtain that absolute changes provide larger coefficients implying marginally greater impact on the ESG scores compared to the percentage variation.

Finally, in Table 11 I include the firm color indicators to ascertain whether there are significant differences in the treatment for Brown and Green firms. As dependent variables I use the overweight ratio in columns 1 and 2 and the Refinitiv ESG score in columns 3 and 4. I regress the dependent variables on interactions of the firm type indicators and the one or two-year percentage changes in emissions. Thereby, I get only partly significant results, which imply that the two-year percentage change does not impact the Refinitiv ESG score. This indicates the need for further validation since Refinitiv's methodology states that, to arrive at the final ESG score in environment sustainability, they employ percentage changes in emissions as a metric.

VI. Discussion

Applying Hartzmark and Shue's (2023) conclusions globally requires a nuanced approach, as US and international markets differ significantly in various aspects such as regulations, reporting standards, screening practices, and terminology (Louche & Lyndenberg, 2006). In contrast to other countries where disclosure is still voluntary and irregular, the US has more abundant and reliable emissions data due to stricter emissions regulations like the

EPA Greenhouse Gas Reporting Programme[5] and widely used sustainability reporting frameworks like SASB (Serafeim & Yoon, 2022; Brandon et al., 2022). The uniformity of investor norms and sophistication in the US market could also potentially augment the efficacy of methods such as investor screens and interaction (Dyck et al., 2019). While differences in the sample of this application study are likely accountable for a substantial part of variation in results, some discrepancy may arise from the nature of the sample. This empirical analysis' narrow time frame and small sample size may have reduced the statistical ability to identify long-term impacts. Nevertheless, it is important to consider that I cannot totally rule out the potential of spurious correlations that might have affected Hartzmark and Shue's (2023) first findings. If their results are entirely true as is, the implications of their findings are very far reaching.

Other research, like a study by Yu et al. (2021) on Chinese companies, also demonstrate that financial constraints can impair green technological innovation and implementation. Nevertheless, additional research from Meinerding et al. (2023) suggests that there is asymmetry and complexity in the economic reaction to transition risk shocks. This suggests that the negative impact elasticity for Brown firms may not be universally present. Understanding these disparities necessitates comprehending the institutional frameworks in which Brown firms demonstrate a significant negative impact elasticity.

The generalizability of Hartzmark and Shue's (2023) findings is further complicated by the changing landscape of sustainable investing, which is moving away from simple exclusionary screening and towards more sophisticated tactics (Tang, 2022). There is various recent evidence of institutional investors positively impacting the environmental performance of their investments through engagement (Kordsachia et al., 2022; Broccardo et al., 2022; Alda, 2019). The seeming absence of this aspect in Hartzmark and Shue's (2023) reflection on current investment methods suggests the possibility that though significant, the results do not translate to the practical environment of sustainable investing.

VII. Limitations and Further Research

This study adds notably to the knowledge of the potential drawbacks of the dominant sustainable investing strategy. However, there are several limitations that present starting points for further research. First, due to constraints in data availability, the analysis is restricted to a

[5] https://www.epa.gov/ghgreporting

comparatively small sample of globally dispersed firms during a relative short period of time when looking at the effects of sustainable investments. More conclusive results for the generalizability of the negative impact elasticities of Brown firms would likely be obtained by increasing the sample size and horizon, particularly with regard to markets outside of the US.

Furthermore, because of data limitations, the analysis does not differentiate between the individual monitoring efforts of UN PRI signatories. This gap provides a rich environment for further study to obtain a more detailed picture of the impact of sustainable institutional investors.

Also, the scarcity of data makes it difficult to evaluate large institutional investors' use of sustainable investment strategies worldwide. Although suggestive data indicates that exclusionary screening predominates, more detailed information on the methods employed by significant institutions worldwide would enable direct examination of the most common ways. This information would also make it possible to examine if some sustainable investing strategies work better at encouraging Brown firms to become Green.

Lastly, it should be noted that there are probably more intricate relationships between corporate environmental effect, cost of capital, and financial restrictions that were only partially included here. Further investigation into the mechanisms at work and the boundaries surrounding the effects, utilizing more holistic data and methodologies from the corporate finance and governance sectors, may yield better insights. Gaining a sophisticated grasp of how sustainable investing affects company behavior and environmental performance will only become more important as it gains popularity. This study underscores essential variables to take into account for the subject matter, but its shortcomings emphasize the necessity of further study on sustainable finance and its effects on the environment is needed.

VIII. Conclusion

This paper investigates the applicability of Hartzmark and Shue's (2023) findings regarding the unexpected consequences of the dominant sustainable investing strategy in a worldwide setting. The main realization is that the prevalent tactic of selling off Brown firms does not have the desired effect of lowering emissions. Rather, the analysis shows that emissions from Brown firms vary significantly and that variations in capital costs have a greater impact on their environmental impact than for Green firms. This suggests that taking money away from Brown firms could lead to an increase in emissions. Furthermore, the study reveals that there is a complex relationship between financial distress and environmental performance.

The study also explores the shortcomings of ESG ratings, emphasizing that they are based more on projected advancements rather than on sustainability performance as of right now. From a worldwide standpoint, it is evident that although the general trend of Brown firms having a higher emission variability persists, the specific dynamics differ in various markets because of legal, cultural, and other factors. This highlights how difficult it is to make truly sustainable investments and how sophisticated methods that take into account the particulars of various markets and industries are needed. The results call for a review of the present sustainable investment strategy and support a more all-encompassing approach that incorporates Brown and Green companies in the net zero pursuit.

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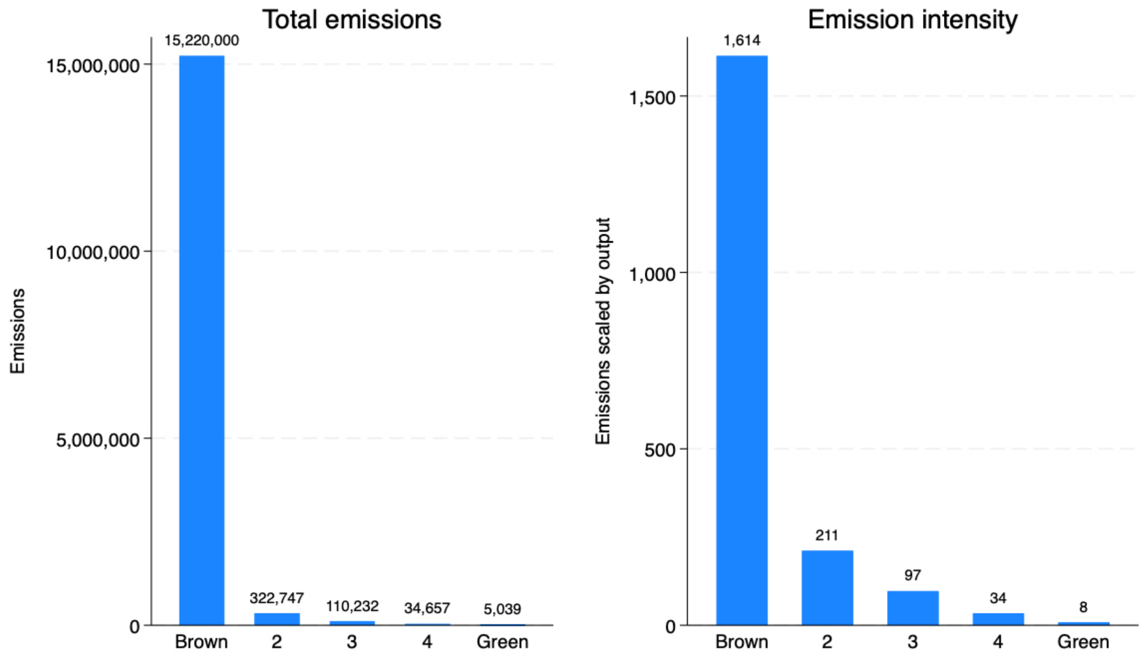
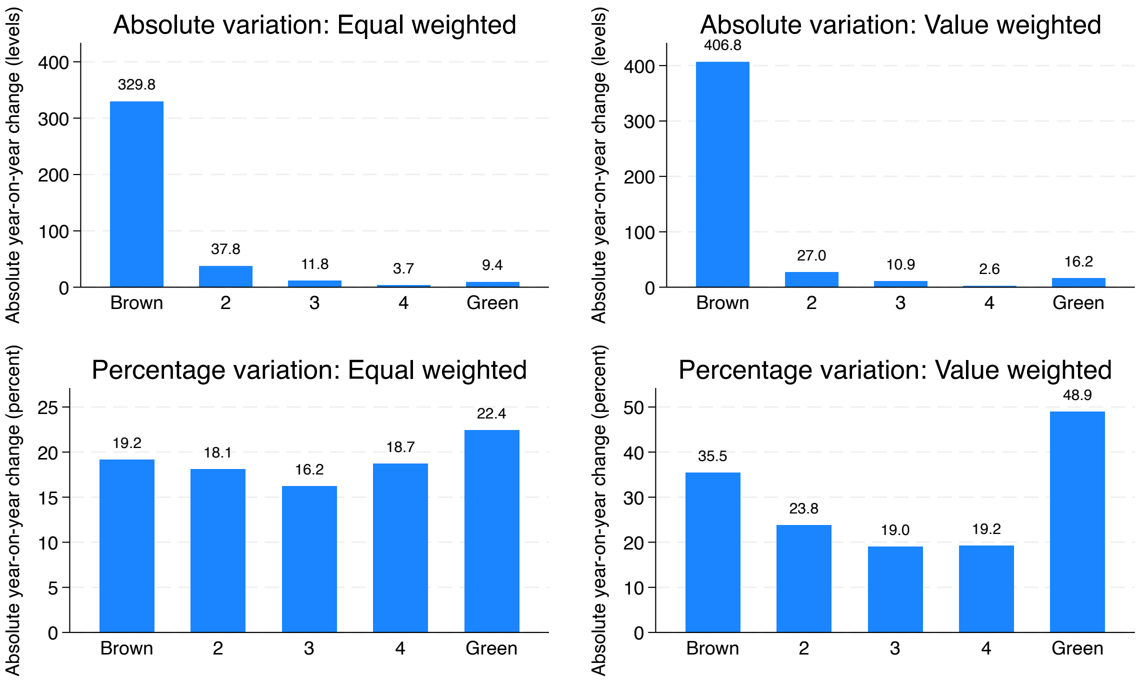
Figure 1: Emissions by quintile



The figure depicts the average emissions by emissions quintile. The quintiles are computed at firm-level segmenting the firms within each fiscal year based on their total scope 1 and scope 2 greenhouse gas emissions. Quintile 1 compromises the firms with the highest emissions, the Brown firms, while Quintile 5 is made up of the low emitting Green firms. The panel on the left measures emissions as total scope 1 and 2 emission of tons of CO_2 equivalents. The panel on the right uses emission intensity as measurement unit, which is defined by total scope 1 and 2 emissions over revenue in units of tons of CO_2 equivalents per million dollars.

Figure 2: Year-on-year changes in emissions by quintile



The figure illustrates the absolute level and percentage year-on-year variation in emission intensity by quintiles for the levels of emission intensity. The quintiles are calculated within each fiscal year according to the level of emission intensity. The panels on the left weight the observations equally, while the panels on the right apply weights according to the firms' relative market capitalizations of the CRSP market size of their respective SIC2 industries. In the bottom panels, year-on-year percentage change values are winsorized at the 1% level.

Table 1: Summary statistics

	N	Mean	SD	p10	p50	p90
Total Emissions	1,704	3.13	18.88	0.00	0.11	2.32
Emission intensity	1,704	391.94	1,315.59	2.19	45.01	748.53
Absolute changes	1,420	77.60	273.04	0.21	4.77	145.38
Absolute percentage changes	1,420	95.77	2,358.31	2.28	13.13	51.56
Annual returns	1,704	12.28	54.11	-36.55	4.42	62.11
Industry annual returns	1,704	14.55	30.04	-16.43	8.15	50.01
ΔICC	1,068	-0.84	6.61	-8.42	-0.91	6.87
ΔIndustry ICC	1,068	-0.47	3.03	-4.25	-0.82	3.77
ΔICC composite	1,074	-0.78	5.42	-6.53	-0.56	4.84
ΔIndustry ICC composite	1,074	-0.14	1.87	-2.43	-0.08	1.78
Number of firms	284	284	284	284	284	284

The table outlines the summary statistics for the focal variables of the analysis. Total emissions describes the sum of Scope 1 and 2 greenhouse gas emission measured in millions of tons of CO_2 equivalents. Emission intensity scales total emissions by firm revenue and is measured in tons of CO_2 equivalents per million dollars of revenue. Absolute changes defines the absolute year-on-year change of the level of emission intensity, while absolute percentage changes refers to the absolute value of the fractional year-on-year changes. Annual returns outlines the yearly financial returns. Industry annual returns describes the yearly value-weighted returns within each SIC2 industry excluding the contribution of the focal firm. ΔICC refers to the year-on-year change of the implied cost of capital calculated following Fama and French (2015, 2017) and is measured in percent. Similarly, ΔIndustry ICC defines the year-on-year change of the implied cost of capital within each SIC2 industry excluding the focal firm. ΔICC composite and ΔIndustry ICC composite outline the year-on-year change of the simple average of ICC's following the methods of Gebhardt et al. (2001), Hou et al. (2012), Chattopadhyay et al. (2022), and Fama and French (2015, 2017) on firm-level and industry-level excluding the focal firm, respectively.

Table 2: Emission intensity per quintile over time

	2017	2018	2019	2020	2021	2022	Total
1	1819.2	1721.7	1719.9	1754.1	1857.8	1631.5	1751.5
2	151.6	145.5	140.9	152.4	156.5	144.6	148.5
3	48.7	46.7	45.5	46.4	44.5	47	46.5
4	14.2	14.8	15.2	14.8	14.6	14.4	14.7
5	2.6	2.6	2.4	2.3	2.5	2.4	2.5
Total	428.1	405.6	398.1	424	371.9	323.8	391.9

The table depicts the evolution of emission intensity over a horizon of 5 years, from 2017-2022. The rows are sorted into emission intensity quintiles allocated based on the rank of emission intensity with 5=Green and 1=Brown. Each quintile contains 20% of the data sample. The table values represent the mean emission intensities per year within each quintile. Emission intensity is computed as the sum of scope 1 and 2 emissions over the firms' respective revenues. The unit of measurement is tons of CO_2 equivalents per million dollars of revenue. The years are defined based on fiscal years.

Table 3: Absolute change in emission intensity by quintile

	Absolute changes in emission intensity		
	(1)	(2)	(3)
Quintile2	-46.9*	-190.9	-4.3
	(24.4)	(127.2)	(15.9)
Quintile3	-68.8**	-201.0*	-1.6
	(28.1)	(113.0)	(23.5)
Quintile4	-90.4***	-176.4*	-83.3
	(33.6)	(98.2)	(57.2)
Quintile5	-112.9***	-188.6*	-95.3*
	(33.6)	(97.6)	(54.8)
Year FE	Yes	Yes	No
Value-weighted	No	Yes	No
Within SIC2 industry	No	No	Yes
N	1,420	1,420	1,420
R^2	0.022	0.568	0.005

The table displays the year-on-year change in emission intensity by quintiles allocated according to emission intensity. The dependent variable represents the absolute year-on-year change of emission intensity, the scope 1 and 2 emissions in tons of CO_2 equivalents scaled by million dollars of revenue. I regress the dependent variable on emission intensity quintile dummies, allocated by emission intensity in year *t*. Quintile 1 representing Brown firms is the omitted category and serves as a baseline for the coefficients of Quintiles 2-5. The coefficients indicate the difference of absolute year-on-year change in emission intensity to Brown firms. Columns (1) and (2) use quintiles calculated on firm-level, while column (3) uses quintiles computed within each year × SIC2 industry. In column (1) and column (2) I adjust for year fixed effects. Further, column (2) weights observations according to their relative industry market value calculated by their CRSP market capitalization over the total SIC2 industry market value in any given year. Standard errors are clustered at the firm-level and displayed in parentheses, significances are indicated by *, **, and *** and indicate the 10%, 5%, and 1% significance thresholds respectively.

Table 4: Emissions and financial performance

	Absolute changes in emission intensity	
	(1)	(2)
Brown × Annual return	-0.369*	
	(0.199)	
Neutral × Annual return	0.026	
	(0.032)	
Green × Annual return	0.030	
	(0.022)	
Brown × Industry annual return		-0.014
		(0.476)
Neutral × Industry annual return		0.089
		(0.095)
Green × Industry annual return		-0.048
		(0.102)
p-value: Brown × X = Green × X	0.045	0.942
Type FE	Yes	Yes
Year FE	Yes	Yes
N	1,420	1,420
R^2	0.026	0.021

The table shows the year-on-year change in emission intensity relating to the previous-year changes in firm or industry level financial returns. The dependent variable represents the absolute year-on-year change of emission intensity, the scope 1 and 2 emissions in tons of CO_2 equivalents scaled by million dollars of revenue. I regress the dependent variable on interaction terms of indicators of the firm type (i.e. Brown, Green, or Neutral) and the previous-year firm-level or industry-level financial performance in percent. The columns include year fixed effects and also type fixed effects to control for whether the firm is Brown, Neutral, or Green. In the bottom section I also report the p-value of a simple F-test which hypothesizes that the Brown and Green interaction coefficients do not significantly differ. Standard errors are clustered at the firm-level and displayed in parentheses, significances are indicated by *, **, and *** and indicate the 10%, 5%, and 1% significance thresholds respectively.

Table 5: Long-run emissions and financial performance

	4-year changes in emissions			
	(1)	(2)	(3)	(4)
Brown × Annual returns	0.195			
	(0.248)			
Neutral × Annual returns	0.114			
	(0.086)			
Green × Annual returns	0.096			
	(0.108)			
Brown × Industry annual returns		1.235		
		(0.789)		
Neutral × Industry annual returns		-0.002		
		(0.056)		
Green × Industry annual returns		0.117		
		(0.140)		
Brown × Low returns			-207.450	
			(214.744)	
Neutral × Low returns			-7.303	
			(7.454)	
Green × Low returns			-0.225	
			(2.200)	
Brown × Low industry returns				-207.450
				(214.744)
Neutral × Low industry returns				-7.303
				(7.454)
Green × Low industry returns				-0.225
				(2.200)
p-value: Brown × X = Green × X	0.715	0.159	0.336	0.3360
Type FE	Yes	Yes	Yes	Yes
Year FE	Yes	Yes	Yes	Yes
N	568	568	568	568
R^2	0.015	0.030	0.035	0.035
Number of firms	284	284	284	284

The table shows the long-run change in emission intensity relating to the previous-year changes in firm or industry level financial returns and indicators for low financial performance. The dependent variable represents the four-year change of emission intensity. I regress the dependent variable on interaction terms of indicators of the firm type (i.e. Brown, Green, or Neutral) and the previous-year firm-level or industry-level financial performance in percent. I also regress the emission changes on interactions of the firm type marker and an indicator for low annual returns. This low returns indicator is equal to one when the annual returns of the respective fiscal year are in the bottom decile of the sample. The columns include year fixed effects and type fixed effects to control for whether the firm is Brown, Neutral, or Green. In the bottom section I also report the p-value of a simple F-test which hypothesizes that the Brown and Green interaction coefficients do not significantly differ. Standard errors are clustered at the firm-level and displayed in parentheses, significances are indicated by *, **, and *** and indicate the 10%, 5%, and 1% significance thresholds respectively.

Table 6: Emissions and financial distress

	Absolute changes in emission intensity			
	(1)	(2)	(3)	(4)
Brown × Low Z-score	-6.87			
	(83.70)			
Neutral × Low Z-score	7.49*			
	(3.97)			
Green × Low Z-score	3.06			
	(2.66)			
Brown × Low interest coverage		-6.87		
		(83.70)		
Neutral × Low interest coverage		7.49*		
		(3.97)		
Green × Low interest coverage		3.06		
		(2.66)		
Brown × Low returns			-6.87	
			(83.70)	
Neutral × Low returns			7.49*	
			(3.97)	
Green × Low returns			3.06	
			(2.66)	
Brown × Low industry returns				-6.87
				(83.70)
Neutral × Low industry returns				7.49*
				(3.97)
Green × Low industry returns				3.06
				(2.66)
p-value: Brown × X = Green × X	0.906	0.906	0.906	0.906
Type FE	Yes	Yes	Yes	Yes
Year FE	Yes	Yes	Yes	Yes
N	1,420	1,420	1,420	1,420
R^2	0.021	0.021	0.021	0.021
Number of firms	284	284	284	284

The table outlines the year-on-year change in emission intensity relating to indicators for financial distress. The dependent variable represents the absolute year-on-year change of emission intensity. I regress the dependent variable on interaction terms of indicators of the firm type (i.e. Brown, Green, or Neutral) and indicators for a high likelihood of financial distress according to the relative firm Altman Z-Score, interest coverage ratio, and financial returns. The low Altman Z-score indicator is equal to one if the firm's Z-score is in the bottom decile of the sample. The low interest coverage indicator is equal to one if the interest coverage ratio of the firm is in the bottom decile of the sample. The low returns indicator is one if the annual returns of the respective fiscal year is in the bottom decile of the sample. The columns include year fixed effects and type fixed effects. In the bottom section I also report the p-value of a simple F-test which hypothesizes that the Brown and Green interaction coefficients do not significantly differ. Standard errors are clustered at the firm-level and displayed in parentheses, significances are indicated by *, **, and *** and indicate the 10%, 5%, and 1% significance thresholds respectively.

Table 7: Emissions and implied cost of capital

	Absolute changes in emission intensity			
	(1)	(2)	(3)	(4)
Brown × ΔICC	5.02			
	(3.18)			
Neutral × ΔICC	-0.69*			
	(0.37)			
Green × ΔICC	-1.24**			
	(0.61)			
Brown × ΔIndustry ICC		12.66**		
		(6.21)		
Neutral × ΔIndustry ICC		-3.69*		
		(1.99)		
Green × ΔIndustry ICC		-4.39		
		(2.77)		
Brown × ΔICC composite			-4.24	
			(6.08)	
Neutral × ΔICC composite			-0.81**	
			(0.38)	
Green × ΔICC composite			-0.17	
			(0.51)	
Brown × ΔIndustry ICC composite				3.20
				(8.85)
Neutral × ΔIndustry ICC composite				-4.27**
				(1.99)
Green × ΔIndustry ICC composite				-5.99**
				(2.51)
p-value: Brown × X = Green × X	0.055	0.006	0.498	0.320
Type FE	Yes	Yes	Yes	Yes
Year FE	Yes	Yes	Yes	Yes
N	1,068	1,068	1,074	1,074
R^2	0.030	0.047	0.023	0.026
Number of firms	217	217	217	217

The table shows the year-on-year change in emission intensity following changes in the firm-level or industry-level implied cost of capital. The dependent variable represents the absolute year-on-year change of emission intensity, the scope 1 and 2 emissions in tons of CO_2 equivalents scaled by million dollars of revenue. I regress the dependent variable on the year-on-year change on measures of the implied cost of capital (ICC) at the firm level and industry level excluding the focal firm. The ICC is derived following the methodology of Fama & French (2015, 2017). The ICC composite is computed by the simple average of ICC measures calculated based on the methods of Gebhardt et al. (2001), Hou et al. (2012), Chattopadhyay et al. (2022), and Fama and French (2015, 2017). All of the regressions include controls for year and type fixed effects. In the bottom section I also report the p-value of a simple F-test which hypothesizes that the Brown and Green interaction coefficients do not significantly differ. Standard errors are clustered at the firm-level and displayed in parentheses, significances are indicated by *, **, and *** and indicate the 10%, 5%, and 1% significance thresholds respectively.

Table 8: Emissions, productivity, and leverage

	Absolute changes in emission intensity	
	(1)	(2)
Brown × Industry ROA	-12,670***	-51,229***
	(626)	(2,166)
Neutral × Industry ROA	-105	-79
	(88)	(99)
Green × Industry ROA	40	259
	(156)	(202)
Brown × Industry ROA × Low interest coverage (omitted)	-	
Neutral × Industry ROA × Low interest coverage	197	
	(219)	
Green × Industry ROA × Low interest coverage	-179	
	(337)	
Brown × Industry ROA × Firm leverage		158,894***
		(7,996)
Neutral × Industry ROA × Firm leverage		64
		(238)
Green × Industry ROA × Firm leverage		-688
		(491)
p-value: Brown × X × Z= Green × X × Z	0.598	0.000
Type FE	Yes	Yes
Year FE	Yes	Yes
N	120	120
R^2	0.947	0.968
Number of firms	80	80

The table shows the annual change in emission intensity relating to the interactions of leverage and productivity shocks. The dependent variable represents the absolute year-on-year change of emission intensity, the scope 1 and 2 emissions in tons of CO_2 equivalents scaled by million dollars of revenue. I regress the dependent variable on interaction terms of indicators of the firm type (i.e. Brown, Green, or Neutral) and return on assets (ROA). In column 1 and 2 I extend the interaction terms by a low interest coverage control indicator that is equal to one if the firm's interest coverage ratio is in the bottom decile of the sample and firm leverage ratio, respectively. The columns include year, industry, and type fixed effects. In the bottom section I report the p-value of a simple F-test which hypothesizes that the Brown and Green interaction coefficients do not significantly differ. Standard errors are clustered at the firm-level and displayed in parentheses, significances are indicated by *, **, and *** and indicate the 10%, 5%, and 1% significance thresholds respectively.

Table 9: Emission changes and portfolio holdings

	Overweight in PRI portfolios			
	(1)	(2)	(3)	(4)
Total emissions	1.080	0.074	1.039	0.709
	(0.903)	(0.891)	(0.837)	(0.738)
Absolute change (1y)	-0.043			
	(0.280)			
Absolute change (2y)		-1.184		
		(1.425)		
Percentage change (1y)			-1.413	
			(2.242)	
Percentage change (2y)				-3.095
				(5.307)
Year FE	Yes	Yes	Yes	Yes
N	30	24	30	24
R^2	0.250	0.266	0.251	0.257
Number of firms	8	8	8	8

The table displays the relation between the overweight of firms in PRI pledged portfolios and the level and percentage change of emissions. The dependent variable measures by how much institutional investors that pledged for the PRI goals overweight the respective firms in their portfolios compared to a value-weighted market portfolio. The overweight variable is computed as $\frac{w_{PRI}-W_{mkt}}{w_{mkt}} * 100$, where w_{PRI} refers to the weight in the PRI investor portfolio and W_{mkt} describing the weight of the firm in a value-weighted market portfolio based on CRSP market values. I regress the dependent variable on the year-on-year and two-year changes of emission intensity in absolute levels and percentage terms. In all columns I control for the firm total emission intensity level and year fixed effects. Standard errors are clustered at the firm-level and displayed in parentheses, significances are indicated by *, **, and *** and indicate the 10%, 5%, and 1% significance thresholds respectively.

Table 10: Different emission change measurements and ESG score

	ESG Score			
	(1)	(2)	(3)	(4)
Total emissions	-0.001**	-0.000	-0.001**	-0.000
	(0.001)	(0.001)	(0.001)	(0.001)
Absolute change (1y)	-0.001			
	(0.001)			
Absolute change (2y)		0.001		
		(0.001)		
Percentage change (1y)			0.000	
			(0.000)	
Percentage change (2y)				-0.000***
				(0.000)
Year FE	Yes	Yes	Yes	Yes
N	1,420	1,136	1,420	1,136
R^2	0.371	0.261	0.370	0.261
Number of firms	284	284	284	284

The table displays the relation between the firm ESG score and the level and percentage change of emissions. The dependent variable is the firm's Refinitiv ESG score that is measured based on 186 sub metrics and ranges on a scale from 0-100 (with 100 being most sustainable). I regress the dependent variable on the year-on-year and two-year changes of emission intensity in absolute levels and percentage terms. In all columns I control for the firm total emission intensity level and year fixed effects. Standard errors are clustered at the firm-level and displayed in parentheses, significances are indicated by *, **, and *** and indicate the 10%, 5%, and 1% significance thresholds respectively.

Table 11: Emission percentage changes and incentives

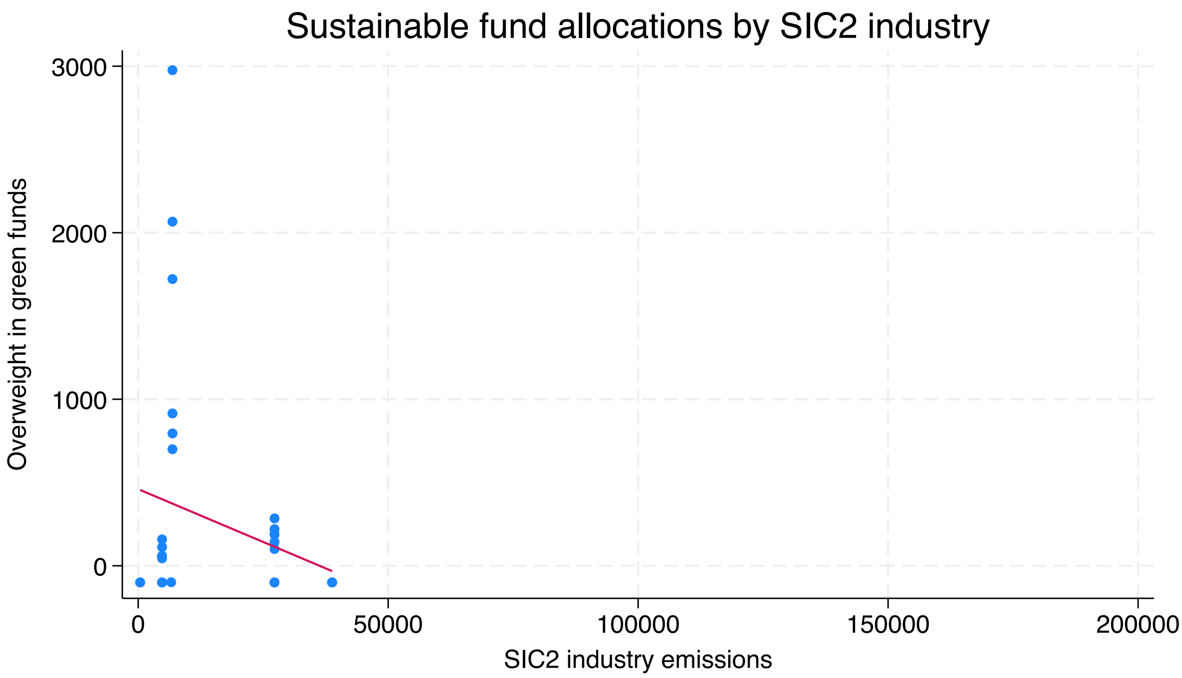
	Overweight in PRI portfolios		Refinitiv ESG Score	
	(1)	(2)	(3)	(4)
Total emissions	0.995	0.041	-0.001**	-0.000
	(0.961)	(0.898)	(0.001)	(0.001)
Brown × Percentage change (1y)	-2.283		0.000	
	(4.873)		(0.000)	
Neutral × Percentage change (1y)	-1.232		0.006***	
	(2.985)		(0.002)	
Green × Percentage change (1y)			0.000	
			(0.005)	
Brown × Percentage change (2y)		-11.846		-0.000***
		(14.685)		(0.000)
Neutral × Percentage change (2y)		-1.014		0.008***
		(4.046)		(0.001)
Green × Percentage change (2y)				0.007
				(0.012)
p-value: Brown × X = Green × X	0.654	0.446	0.996	0.561
Type FE	Yes	Yes	Yes	Yes
Year FE	Yes	Yes	Yes	Yes
N	30	24	1,420	1,136
R^2	0.252	0.267	0.372	0.271
Number of firms	8	8	284	284

The table displays the relation of percentage changes in emissions and PRI portfolio holdings as well as the Refinitiv ESG score. The dependent variable for column 1 and 2 is the firm's overweight in the PRI pledged investor portfolios as defined in Table 9. The dependent variable for column 3 and 4 is the firm's Refinitiv ESG score that is measured based on 186 sub metrics and ranges on a scale from 0-100 (with 100 being most sustainable). I regress the dependent variables on interaction terms between indicators for the firm type (i.e. if the firm is Brown, Neutral, or Green) and one and two-year percentage changes in the firm emission intensity as defined in Table 1. In all columns I control for the firm total emission intensity level, year fixed effects, and type fixed effects. In the bottom section I report the p-value of a simple F-test which hypothesizes that the Brown and Green interaction coefficients do not significantly differ. Standard errors are clustered at the firm-level and displayed in parentheses, significances are indicated by *, **, and *** and indicate the 10%, 5%, and 1% significance thresholds respectively.

Appendix

Additionally, I investigate the issue of non-substitutability with regard to the green transition. Figure A1 illustrates the dispersion of high and low emitting industries with regard to overweight in Green funds. It is apparent that higher emitting industries have less frequent overweights than low emitting, generally Green industries. This underscores the argumentations that sustainable investors generally overinvest in Green firms based on ESG scores derived from relative measures and that proper sorting within industries to support the green transition does predominantly not take place.

Figure A1: Industry overweight in sustainable funds



The figure illustrates the average overweight in green funds for the SIC2 industries, as well as their emissions. The green fund overweight is calculated as described in Table 9. The industry emissions describe the respective industries' emission intensity and refers to the total emissions in tons of CO_2 equivalents scaled by output in millions of dollars.

Table A1: Observations by country

Country	Freq.	Percent
ARE	6	0.35
ARG	6	0.35
AUS	24	1.41
BEL	24	1.41
BRA	18	1.06
CAN	78	4.58
CHE	30	1.76
CHL	18	1.06
CHN	252	14.79
COL	6	0.35
DEU	66	3.87
DNK	18	1.06
ESP	12	0.7
FIN	18	1.06
FRA	36	2.11
GBR	78	4.58
GEO	6	0.35
GRC	12	0.7
HKG	138	8.1
IND	24	1.41
ISR	6	0.35
ITA	54	3.17
JPN	84	4.93
KOR	36	2.11
KWT	6	0.35
LUX	12	0.7
MAC	6	0.35
MEX	18	1.06
MYS	36	2.11
NLD	24	1.41
NOR	30	1.76
NZL	6	0.35
PER	12	0.7
PHL	24	1.41
POL	18	1.06
SGP	24	1.41
SVN	6	0.35
SWE	36	2.11
THA	18	1.06
TUR	30	1.76
TWN	72	4.23
USA	270	15.85
ZAF	6	0.35
Total	1,704	100

The table shows the total number of observations from 2017-2022 by country in the sample.

Official statement of original thesis

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