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GRA19703 Master Thesis

Master of Science in Sustainable Finance
Master of Science in Finance

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Revisiting the Big Three and their role in global corporate carbon emissions [1]

Abstract

Emissions from listed companies are responsible for 40% of global greenhouse gas emissions (Preston & Ward, 2021), which makes investors a critical change agent in the transition to a net zero economy. We examine the role of the three biggest institutional investors, the Big Three (Blackrock, Vanguard and State Street), on the reduction of corporate carbon emissions. The Big Three represent some of the largest owners of US listed companies and thus could have substantial voting power and influence over firms' emissions. Using methodologies from Azar et al.'s (2021) original Big Three study, we find that the Big Three are associated with reduced corporate carbon emissions from 2014-2022. We do not find that the association between the Big Three and emission reductions have increased over time, nor do we find evidence that larger Big Three holdings result in larger emission reductions. These last two findings are contrary to Azar et al.'s (2021) results, and we hypothesize that the differences are due to our broader firm coverage, exclusion of estimated data from our sample, and our use of more appropriate fixed effects.

[1] We thank Alessandro Graniero, Asja Bosnic, Igor Kadach, Bruno Gerard, Olav Syrstad and Karoline Palmer for their wonderful advice, comments, suggestions and insights.

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1 Introduction and Motivation

Listed company emissions are responsible for 40% of greenhouse gas (GHG) emissions (Preston & Ward, 2021), and firms' actions are critical in combating the urgent threat of climate change. There are many ways firms can be pressured to reduce their emissions, such as implementing stricter environmental regulations, increasing borrowing costs and conducting climate activism. We are interested in finding out which of these methods has been most effective in inducing firms to cut their carbon emissions. To explore this further, we narrow our scope down to institutional investor pressure.

Institutional owners can pressure firms to reduce emissions through the threat of divestment and stewardship (monitoring, engagement and voting). Benlemlih et al. (2022) examine institutional investors in the UK and US, and find that institutional ownership of both active and passive owners is associated with reduced firm GHG emissions. Their study builds upon Azar, Duro, Kadach & Ormazabal's (2021) paper, that looks more specifically at the US based "Big Three" (Blackrock, Vanguard and State Street Global Advisors)[2]. Their results indicate that only the Big Three are effective in inducing firms to reduce emissions, not institutional investors in general. The Big Three are primarily passive index investors for which threat of divestment is not a relevant tool to influence the behavior of their portfolio firms.

This thesis builds upon Azar et al.'s (2021) findings that Big Three ownership is associated with reduced firm emissions. A limitation of both studies is in their use of total[3] estimated and reported CO_2 emissions as the response variable. This definition contains three major sources of uncertainty: errors from the estimation of CO_2 emissions, errors from the inclusion of unreliable Scope 3 data, and variations in non-

[2] Defined as the institutional investors with the highest value of assets under management (AUM). Today, the Big Three are no longer comprised of Blackrock, Vanguard and State Street (Thinking Ahead Institute, 2022)) as State Street has been surpassed by Fidelity Investments. For comparability with the Azar et al. (2021) paper, we continue using State Street as part of the Big Three.

[3] Total emissions are defined as the sum of estimated and reported Scope 1, 2 and 3 emissions.

reported accounting factors such as changes in emissions factors used to calculate Scope 1 emissions.

We investigate whether using alternative carbon emission measures specifically constructed to minimize these effects of carbon accounting uncertainty alter inferences about the role of passive investors in shaping portfolio firms emission policies.

We begin by obtaining company and carbon data for all of Big Three's holdings from 2005 to 2018 and recreating Azar et al.'s (2021) paper. We run a panel data regression on total carbon emissions and institutional holdings, separated into Big Three and Non-Big Three holdings. Omitted variables are controlled using industry, firm, year and country fixed effects. We also control for other biases using firm-specific control variables and run additional robustness tests by using first difference estimators and regressing non-negligible changes in holdings on emissions. We then extend Azar et al.'s (2021) models by re-running the models with our alternative specifications of CO_2 emissions to minimize the effect of each source of carbon accounting uncertainty. We then extend the study period to 2014 to 2022 and re-run the analysis.

Comparable to Azar et al. (2021), we find that Big Three ownership is associated with reduced firm emissions. However, we do not corroborate their findings that the association becomes stronger with time and increased holding size. Our original hypothesis that dubious Scope 3 data represented the largest source of uncertainty was rejected, and we find that estimated emissions causes bias.

Our contribution is the extension of the analysis to later sample periods post-Paris Agreement, and additional robustness testing of Azar et al.'s (2021) analysis through the removal of sources of data uncertainty.

The remainder of this paper is organized as follows. In Section 2, we review the literature. In Section 3, we develop hypotheses and introduce the models that we use for analysis. In Section 4, we discuss the data, its limitations and how the sample was constructed. In Section 5, we analyze the results. Section 6 concludes.

2 Literature Review

Azar et al. (2021) and Benlemlih et al. (2022) find that engagement, proxied by institutional ownership, results in reduced total carbon emissions. It remains to be seen whether their findings are robust to alternative specifications of CO_2 emissions. We address this question in our thesis.

In this section, we review why institutional investors care about ESG issues, the mechanisms through which they affect change, how effective their efforts are and the limitations in Azar et al.'s (2021) paper. In Section 3, we go into further detail about the limitations and discuss how we address them in our research methodology.

2.1 Institutional Investors' Incentives to Reduce GHG Emissions

Institutional investors derive 70 - 80% of their revenue from management fees based on percentages of assets under management or AUM (Blackrock Inc., 2023; State Street, 2022). On the one hand, passive investors compete on price by providing funds with the lowest fees, which implies that they minimize costs and do as little as possible in terms of governance. On the other hand, by publicizing their commitment to ESG issues, they improve their reputation and ethical legitimacy as responsible investors. In turn, this may attract more inflows, stems outflows, and increases assets under management (AUM) and revenues earned via fees (Barzuza et al., 2019), Dimson et al., 2018).

From a portfolio management perspective, attention to ESG may increase portfolio value. Bolton & Kacperczyk (2021) find that high emissions are linked to lower valuations, and engagements on environmental and social (ES) issues results in higher compounded annual returns up to 18 months after the engagement (Dimson et al., 2015).

Attention to ESG issues may also reduce portfolio firms' compliance costs in addressing environmental regulations, as well as downside risk (Bansal et al., 2016, Hoepner et al., 2016, and Krueger et al., 2020).

Indexers like the Big Three have an even greater incentive to manage their ESG risks and internalize externalities than other institutional investors. They own most of the equities in the market and are more broadly exposed to risks from externalities. It is in

their best interest to minimize potential costs and maximize potential benefits of those externalities (Dimson et al., 2015), particularly as they cannot divest from individual companies (Carleton et al., 1998; Romano, 1993). Indexers have the benefit of a long time horizon and are interested in long-term profits. They are more likely to care more about a firm's corporate governance or strategy than short-term profits, and have the patience to wait for their engagement efforts to come to fruition (Krueger et al., 2020; McCahery et al., 2016).

2.2 Mechanisms through which Institutional Investors Address Sustainability Concerns

There are many approaches to socially responsible investing (SRI), but the best suited to institutional investors are divestment, stewardship and integration of ESG factors in investment decisions.

As the Big Three are indexers, they are unable to divest or use ESG factor integration to exercise their social responsibility. Therefore, they only have stewardship with portfolio firms at their disposal. Stewardship comprises monitoring, voting and engaging with portfolio companies, and Azar et al. (2021) analyze engagement as the mechanism by which the Big Three influence CO_2 emissions.

Engagement can take on two forms, passive and active. Passive engagement includes publishing opinion pieces, making supporting activists, public announcements, writing expectations documents to the board and management, and establishing a voting policy in favor of principles or using an external company that can attend meetings and vote on their behalf.

Active engagement includes activism, direct engagement with management and the board, and the formation of coalitions. Private active engagement appears to be the dominant mechanism of engaging for stronger environmental and social (ES) performance according to Dyck et al. (2019) and McCahery et al. (2016). Active engagement places more demand on time and resources, and given their enormous number of portfolio companies, institutional investors therefore target their engagements to companies where they are most likely to have most success.

It is unclear which engagement mechanisms are used by the Big Three, as their engagement data is not particularly descriptive. For example, Blackrock engagement data is given as a binary variable of engaged or not engaged. For State Street, engagement is given as a binary variable separated by topic such as pay, environmental and social, governance, proxy content and multiple engagements. Vanguard's engagement records are similar, but separated by topic on board, strategy, executive compensation and governance.

While Azar et al. (2021) considers engagement as the mechanism through which the Big Three affect emissions, we argue that they also influence firms directly through voting, and indirectly by influencing other investors with their voting and public actions. Griffin (2020) find that the Big Three "already possess sufficient voting power to determine the outcome of 50% of the environmental and social proposals and approximately 65% of governance proposals."

2.3 Effectiveness of Engagement in Reducing GHG Emissions

Studies on the effectiveness of engagement in achieving outcomes are few, due to difficulties with engagement data. No global database of private and public engagements exists, as this information is privately held and not publicly disclosed by all asset managers consistently across all years (Dyck et al., 2019b). The engagement data that IS available is not very detailed or comparable across investors. The Big Three report their engagement as a binary variable of engaged or not engaged, with no further details on the content of that engagement. We do not know whether the engagement is relevant to emissions reductions, or the degree to which the investor attempted to influence a firm. This makes it difficult to link the effectiveness of engagement data directly to an improvement in ESG outcomes.

Since engagement data has a large number of missing values and is not linearly related to emissions, it does a poor job at capturing the effects of the Big Three's actions on CO_2 emissions. In addition, there may be other mechanisms besides engagement, such as voting, that has may be used to affect firm emissions. For this reason, Azar et al. (2021) use ownership percentage as a proxy for the probability of engagement. They regress percentage of Big Three ownership and non-Big Three institutional ownership

on total CO_2 emissions. Benlemlih et al. (2022) use GHG Intensity, calculated as total CO_2 emissions divided by sales revenue, in addition to absolute emissions.

Azar et al. (2021) observe a strong and robust negative association between Big Three ownership and subsequent carbon emissions among MSCI index constituents. They do not observe that other institutional investors (Non-Big Three) have a similar effect on portfolio firms' carbon emissions. When studying the effects of Big Three ownership on firm emissions, it is important to distinguish between whether investors have reduced firm emissions, or whether they were simply good at choosing pro-ESG firms that had emission reductions on their agenda. This endogeneity issue is addressed by studying index investors such as the Big Three, who cannot choose who they invest in, but invest according to an index.

Benlemlih et al. (2022) build upon their work and analyze all institutional investors instead of separating them into Big Three and Non-Big Three. They build their sample using constituents of the FTSE All-Share and Russell 3000 index in the time period 2010 to 2019, and exclude financial firms due to their different reporting and regulatory standards. They do not separate firms into MSCI and non-MSCI, but divide them into groups with low and high litigation costs based on prior literature that posits that environmental violations incur large litigation costs that deters the firm from wasting resources. Unlike Azar et al. (2021), they find that the engagement efforts of all institutional investors, not just the Big Three, result in reduced emissions. Their findings are robust to endogeneity issues, which they deal with through a two-stage least squares approach.

Azar et al. (2021) and Benlemlih et al. (2022) both use total estimated and reported GHG emissions, which is problematic given the current limitations in carbon accounting. In the next section, we discuss how these limitations could affect their analysis and propose new models.

3 Hypothesis Development & Research Methodology

In this section, we introduce our research questions and the models used to answer them. We first look at the aggregate effect of Big Three ownership on levels of total estimated and reported CO_2 emissions, defined as the sum of Scope 1, 2 and 3. To determine the sources of emission reductions, we breakdown the aggregate effect of Big Three ownership by investor and scope type.

Next, we explore the association of Big Three holdings with firm emissions over time. We breakdown the aggregate effect by year to evaluate the relationship between Big Three ownership and total CO_2 emissions year by year.

Finally, we investigate the effect of Big Three holding size and increases in holdings on firm emissions. We use different specifications such as meaningful changes in Big Three ownership and ownership thresholds to analyse if larger holdings result in larger emission reductions. We base our methodology on tests replicated from Azar et al.'s (2021) paper.

Our analysis is impacted by limitations in carbon accounting, which is a relatively new field that lacks standardization and is rife with poor quality data (Gerard, 2023; Ducoulombier, 2021; Juliff & Nilsen, 2023; Bindman, 2022). We describe these problems in detail in this section and explain why total estimated and reported emissions is a noisy measure of emissions. We propose the re-specification of the dependent variable in all of Azar et al.'s (2021) models to take these limitations into account.

3.1 Aggregate effect of Big Three ownership on total firm emissions

We are interested in the aggregate effect of institutional ownership on firm emissions. We analyze how effective their divestment, selection, voting and engagement efforts are in reducing firm emissions. However, given the poor quality of engagement data (see Section 2.3), we proxy this with ownership percentages, and split institutional ownership into Big Three and Non-Big Three holdings to minimize endogeneity issues caused by the selection bias of active investors stock-picking low carbon companies.

Azar et al. (2021) find that the Big Three engage more with MSCI firms, and split the sample into MSCI and non-MSCI firms. We execute the same split in our analysis.

3.1.1 Hypothesis 1A: Big Three ownership does not result in a reduction of total estimated and reported firm emissions

There are a multitude of protocols for carbon footprint analysis, such as the Publicly Available Specification (PAS) 2050, GHG Protocol Product Standard (GHG Protocol - most widely adopted), and ISO 14067 Carbon Footprint of Products (ISO 14067). Wang et al. (2018) find the carbon footprint of $1m^3$ of Medium Density Fiberboard (MDF), ranged from -667.75 to 816.92kg of CO_2e depending on the protocol used. Different protocols are used worldwide, and reported CO_2 emissions data do not specify the protocol that has been used. In our dataset, Refinitiv does not report the protocol used by the firm in carbon accounting. This leads to inconsistency in the measurement of emissions and makes the comparison of emissions data across countries, firms and years unreliable.

In addition, protocols such as the widely adopted Greenhouse Gas Protocol (GHGP) are constantly evolving. This affects the methodology for carbon accounting and can make comparison across time difficult. For example, emissions are not based on actual sensor data but on calculations which use an emission factor to convert energy usage to emissions. These emission factors change over time, and can result in a change in underlying emissions despite no real changes to the processes and assets generating these emissions. The lack of standardization in carbon accounting leads to open questions:

> Are reductions in firm emissions due to engagement by institutional investors or due to firms switching from one protocol to another or due to a change in carbon accounting protocols which affects the calculation of carbon emissions?

Unfortunately, there is no immediate solution to this challenge until a global standard for carbon accounting is adopted, or data providers such as Refinitiv report the protocol used for reported emissions data.

To complicate matters further, this specification of total firm emissions includes two important sources of uncertainty, Scope 3 and estimated emissions (see Hypothesis 1B

and 1E for further details). After taking these uncertainties into consideration, we do not expect Big Three ownership to result in reduced total estimated and reported emissions, contrary to the Azar et al. (2021) article. Formally, we test the hypothesis that Big Three holdings is associated with higher total reported and estimated emissions.

We test the hypothesis using the following model:

$$Log(CO_2)_{it} = \alpha + \beta \times Big3\_hldg_{it-1} + \gamma \times NonBig3\_hldg_{it-1} + \Phi \times Controls_{it-1} + \tau_t + \delta_i + \epsilon_{it}$$

Equation 1

where:

$$Log(CO_2)_{it} = Log(\text{Total estimated and reported emissions at time } t)$$
$$Big3\_hldg_{it-1} = Blackrock\_hldg_{it-1} + Statestreet\_hldg_{it-1} + Vanguard\_hldg_{it-1}$$
$$NonBig3\_hldg_{it-1} = \text{Total Institutional Ownership}_{it-1} - Big3\_hldg_{it-1}$$
$$Controls_{it-1} = [Size_{it-1}, Log(BM)_{it-1}, ROA_{it-1}, Leverage_{it-1}, PPE_{it-1}]$$
$$\tau_t = \text{year fixed effects, } \delta_i = \text{firm fixed effects, } \epsilon_{it} = \text{error term}$$

3.1.2 Hypothesis 1B: Big Three ownership does not result in a reduction of total reported firm emissions

In the remainder of this section, we expand the analysis in Azar et al.'s (2021) paper to evaluate whether their results are robust to limitations in carbon accounting. The first of these limitations is the estimation of emissions by data providers.

Some companies are mandated to report their emissions depending on their country of operation, whilst others do so voluntarily. Those that are mandated to report according to the countries they operate in, are either high emitters, publicly listed, or large enterprises (Schmidt & Farbstein, 2023). Companies that report voluntarily are generally "greener" than those that do not in terms of Scope 1 emissions (Shi et al., 2023). While new requirements for companies to report are coming into effect, the vast majority of companies do not report their emissions (Bolton et al., 2021).

Therefore, majority of firms do not report, and instead have their emissions estimated by data providers such as Refinitiv and Trucost. These estimation methods differ depending on data vendor, and vendors are not transparent about the methodology they use to estimate emissions. For example, emissions estimates can be based on historical company emissions, energy usage, median industry emissions (Refinitiv, 2022) or

expenditure data (Ung et al., 2016). Emissions based on historical company emissions take the latest available total CO_2 emissions and scale it by the number of employees and net sales. Therefore, estimates can be confoundingly, estimates based on estimates. This leads to the question:

> Are changes in firm emissions a result of meaningful decarbonization efforts by a firm, due to pressure from the Big Three, or simply changes in reporting, either by data providers or firms themselves?

We filter out estimated data, and use only reported emissions in our analysis. To control for high emitters that are mandated to report, we apply industry and country-fixed effects. Azar et al. (2021) and Benlemlih et al. (2022) do not distinguish between reported and estimated emissions in their analysis. We do not expect that the uncertainty introduced by estimated data to change our findings in Hypothesis 1A. That is, we expect that Big Three holdings do not reduce total emissions, as this still contains unreliable Scope 3 data. Formally, we test the hypothesis that Big Three holdings do not reduce total emissions even when we remove estimated emissions as a source of uncertainty.

We use Equation 1 and re-specify the dependent variable as:

$$Log(CO_2)_{it} = Log(Total\ reported\ emissions)_{it}$$

3.1.3 Hypothesis 1C: Big Three ownership results in a reduction of Scope 1 emissions

Scope 1 emissions are emissions that the firm has direct control over, such as emissions from production processes. Since firms have the power to implement changes needed to reduce these emissions, we expect a negative relationship between Big Three ownership and Scope 1 emissions.

We split the CO_2 emissions data set into scopes and look at the Big Three's effect on individual scopes to identify if Big Three ownership leads to a reduction in firm emissions within individual scopes. Formally, we test the hypothesis that Big Three holdings have a negative effect on Scope 1 emissions.

To test our hypothesis, we use Equation 1 and re-specify the dependent variable as:

$$Log(CO_2)_{it} = Log(Reported\ Scope\ 1\ emissions)_{it}$$

3.1.4 Hypothesis 1D: Big Three ownership results in a reduction of Scope 2 emissions

Scope 2 emissions are indirect emissions from purchased steam, electricity, heating and cooling. Firms can switch to lower carbon sources, but only if it is available in the country in which they operate. To control for this, we use country-fixed effects. However, controlling for location of operations is difficult to do in practice as firms have multiple countries of operations which are not reported by Refinitiv. Instead, we control for country fixed effects based on the location of company headquarters. On the one hand this specification could imprecisely reflect the effect of institutional ownership on emissions. On the other hand, it allows us estimate Scope 2 emissions in a meaningful way.

The industry a firm belongs to also plays a role in a firm's Scope 2 emissions. For example, if a firm belongs to an industry that is difficult to decarbonize, such as steel or cement, investor pressure will have a minor effect on Scope 2 emission reductions. To counter this, we apply industry fixed effects in addition to country fixed effects. Formally, we test the hypothesis that Big Three ownership has a negative effect on Scope 2 emissions.

We use Equation 1and re-specify the dependent variable as:

$$Log(CO_2)_{it} = Log(\text{Reported Scope 1 emissions})_{it}$$

3.1.5 Hypothesis 1E: Big Three ownership does not result in a reduction of Scope 3 emissions

Scope 3 emissions are indirect emissions from assets that are not owned or controlled by the firm, but which the firm affects indirectly through its value chain. For example, they can come from parts suppliers (upstream), emissions from consumer use of the product (downstream or end-use) and purchased flights (purchased services). It is optional for firms to report Scope 3 emissions, and many believe that the GHG Protocol lacks clarity in its guidance for the reporting of these emissions (Blackrock, 2022).

The Paris Agreement and other popular net zero initiatives have net zero targets that apply to Scope 1 (direct) and Scope 2 (purchased energy) emissions but not Scope 3 (Bindman, 2022). This is problematic as Scope 3 emissions in industries other than

energy and transportation account for 40 – 50% of total emissions (Hertwich & Wood, 2018). For example, BMW's pledge to be net zero by 2050 applies only to their Scope 1 and 2 emissions, which account for less than 1% of their total emissions. They can claim to be in compliance with the Paris Agreement despite continuing to invest in and produce internal combustion engine (ICE) vehicles. The end use of ICE vehicles results in Scope 3 emissions that account for 81% of BMW's total emissions (BMW, 2022).

However, it is possible that suppliers of portfolio companies are also in our sample set, and their Scope 1 and 2 emission reductions impact companies' Scope 3 emissions that are also in our sample set. For example, if a BMW parts supplier is also in the sample set along with BMW, then institutional ownership can reduce the parts supplier's Scope 1 emissions, which then reduces BMW's Scope 3 emissions.

As a result of the lack of clear reporting guidelines, optionality in reporting and lack of targets for Scope 3 emissions[4], Scope 3 emission data is scarce and of poor quality (Gerard, 2023).

Azar et al. (2021) and Benlemlih et al. (2022) do not consider Scope 3 reporting limitations, and their analysis is based on the sum of Scope 1, 2 and 3 emissions. This raises the issue:

> Does institutional ownership reduce carbon emissions because they have engaged with firms, or is it because firms have decided to omit or reduce Scope 3 emissions in their disclosures?

Formally, we test the hypothesis that Big Three ownership does not result in reduced Scope 3 emissions.

We use Equation 1 and re-specify the dependent variable:

$$Log(CO_2)_{it} = Log(\text{Reported Scope 3 emissions})_{it}$$

3.1.6 Hypothesis 1F: Big Three ownership results in increased carbon intensity

Under the GHG Protocol, the first step in carbon accounting is establishing which emissions a firm is responsible for, known as setting organizational boundaries.

[4] This is not the case in the EU as of the 5th January 2023, when Scope 3 disclosure became mandatory. These changes will not be reflected in the data until the next financial year.

Responsibility can be defined by whether a firm controls (control approach) or owns the operations (equity share approach). For example, 77% of emissions from DHL's operations come from the emissions of partner transportation firms outsourced to deliver transport services (DHL, 2022). Under an equity share approach, DHL does not need to account for these emissions in their Scope 1 disclosure, as they do not own equity in these outsourced firms. However, if they were to use a control approach, these emissions would need to be accounted for in their Scope 1 emissions, as they have operational control over these firms (Gerard, 2023).

Changes in organizational boundaries due to M&As and divestments will affect emissions data. For example, if a firm divests of a holding, then their absolute emissions will decrease despite not having taken any action on reducing emissions. This leads to the following challenge:

> Do firm emissions decrease due to engagement by the Big Three, or have they decreased because they have divested?

If the control or ownership of a firm grows or contracts due to M&A and divestitures, then the absolute level of emissions of the parent company will also change.

Another problem with an absolute emissions measure is the effect of increased firm activity such as sales on emissions. For example, emissions may have decreased as a result of a drop in sales. To some extent, this is effect captured in firm fixed effects, but a separate explanatory variable should be defined to complement total emissions measures.

A potential solution is to use carbon intensity to compare emissions over time. Carbon intensity is defined as $Carbon\ Intensity = \frac{CO_2\ emissions}{Revenue\ in\ '000USD}$. The measure shows how efficient a company is in earning revenues for one unit of carbon. However, this is definition is problematic if the product price is highly variable as in the case of commodities. In these cases, $Carbon\ Intensity = \frac{CO_2\ emissions}{Quantity\ sold}$ is a more meaningful

measure[5]. *Quantity sold* refers to units of product such as barrels of oil. In practice, this is more difficult to implement as we do not have access to sales data in Refinitiv.

Although we propose that changes in organizational boundaries could affect our analysis, empirical literature points to the significance of absolute carbon footprint measures. For example, Bolton & Kacperczyk (2021) show that equity prices are sensitive to absolute levels of emissions but not to emission intensity measures. This begs the questions:

> Is Big Three ownership still meaningful in reducing emissions when we use carbon efficiency instead of absolute emissions? Is carbon efficiency meaningful to Big Three ownership?

We hypothesize that the Big Three improves firm carbon efficiency, but only when Scope 3 emissions are not included. Formally, we test the hypothesis that the Big Three improves firms' ability to generate revenues for one unit of carbon.

To test this, we replace absolute emissions with carbon intensity:

$$Carbon\ Intensity_{it} = \frac{CO_2\ Emissions_{it}}{Revenue\ in\ '000\ USD_{it}}$$

3.2 Effect of individual Big Three investors on firm emissions

3.2.1 Hypothesis 2: Vanguard ownership does not reduce Scope 1 and 2 emissions

We are interested in the effect of each Big Three investor on firm emissions over the sample period, and whether this effect has changed over time. This allows us to identify investors that are responsible for the largest emissions reductions versus those that are merely greenwashing. We want to find out:

> Although promoting ESG helps increase inflows, do firms actually follow through on their green promises, or is it merely greenwashing?

Institutional investors have the power and incentives to be pro-ESG but also a competing fiduciary duty to act in the best interest of their clients, which may not be ESG-promoting. For example, in late 2022, pro-ESG policies were criticized by US

[5] Gerard (2023) mentions carbon efficiency which we have modified to obtain more user friendly coefficients

Republican politicians as putting politics over investor interest (Kerber, 2022). In the wake of this, Vanguard exited from the Net Zero Asset Managers initiative (NZAMi) (Kerber & Hussain, 2022), an initiative by a group of asset managers with USD $59 trillion assets under management (AUM) to support the goal of reaching net emissions by 2050 (NZAMi, 2023). Unfortunately, our sample period does not cover post-2022 and we are not be able to analyze the effect of Vanguard's exit on firm emissions. However, it could indicate that Vanguard has been greenwashing in order to build a green profile to increase AUM.

In another example of competing interests, ShareAction (2023) found that voting by the four biggest asset managers were inconsistent with their public climate commitments, with Blackrock voting backing 16% of environmental resolutions in 2022 versus 72% in 2021. However, given the increasing evidence of private board-shareholder engagements (Carleton et al., 1998b; Bonacchi et al., 2022; McCahery et al., 2016), has Blackrock's ownership been effective overall in reducing emissions?

Formally, we test if Blackrock, Vanguard and State Street have separately reduced emissions, and if these reductions have increased over time.

3.3 Effect of Big Three ownership on firm emissions over time

In the previous section, we evaluated the aggregate effect of the Big Three over the entire sample period on firm emissions. In this section, we look at the evolution of the effect of the Big Three year by year.

3.3.1 Hypothesis 3: The Big Three's effectiveness in reducing Scope 1 and 2 emissions increases over time as focus on climate change intensifies

We hypothesize that the sum of growing awareness, regulations, action and investor pressure will force companies to increase their efforts to reduce their emissions over time. Formally, we test the hypothesis that Big Three ownership reduces firm emissions as awareness and action on climate change intensifies.

To test this, we plot βs from Equation 1 for each year. Formally, we run the model with different definitions of the dependent variable such as total estimated and reported emissions, reported total emissions, Scope 1, Scope 2, Scope 3 emissions and carbon efficiency to evaluate the effect of limitations in carbon accounting.

3.3.2 Hypothesis 4: The effectiveness of the Big Three in reducing emissions increases over time as their holding size and influence increases

In this section, we use another alternate specification to test the persistence of the effects of the Big Three on firm emissions. It takes time for investors to obtain and exert influence on company leadership, and for management to implement the requests of their investors. Therefore, we expect that increased Big Three holdings results in larger emissions reductions over time. That is, if the Big Three engages with a firm in one year, proxied by holdings, do the effects of this engagement continue to later years? Formally, we test if changes in Big Three holdings affect changes in emissions one year and up to sixteen years from when it occurred.

To test this, we re-specify Equation 1 using differing lag values of s.

$$\Delta\_CO_{2,(t-s,t)} = \alpha + \beta \times \Delta\_Big3\_hldg_{(t-s-1,t-1)} + \gamma \times \Delta\_NonBig3\_hldg_{(t-s-1,t-1)} + \Phi \times Controls_{it-1} + \tau_t + \delta_i$$

where $\Delta\_CO_{2i,(t-s,t)}$ is the change in emission between time *t-s* and *t* divided by emissions at time *t-s* while the holdings variables are defined as the change between time *t-s-1* and time *t-1*.

3.4 Effect of Big Three holding size on firm emissions

3.4.1 Hypothesis 5: Non-negligible changes in Big Three ownership results in reduced total firm emissions

We expect that the Big Three have a greater degree of influence on firms when the level of Big Three holdings increases meaningfully[6].

To test this, we re-specify Equation 1 and use changes in Big Three ownership rather than levels. We run the model with different definitions of dependent variable such as total estimated and reported emissions, reported total emissions, Scope 1, Scope 2, Scope 3 emissions and carbon efficiency as described in the first hypotheses. Formally, we test if emissions reductions increase if Big Three holdings increase more than 1%.

[6] A meaningful increase is defined by Azar et al. (2021) as greater than 1 percent.

We replace *Big_hldg* with a dummy variable that indicates if the holdings of the Big Three have increased by over 1% from one time period to the next. The model is specified as:

$$Log(CO_2)_{it} = \alpha + \beta \times Big3\_increase_{it-1} + \gamma \times NonBig3\_increase_{it-1} + \Phi \times Controls_{it-1} + \tau_t + \delta_i + \epsilon_{it}$$

where the indicator variables *Big3_increase* and *NonBig3_increase* take the value of 1 if the respective holdings have increased by more than 1 percentage point from t-2 to t-1, and 0 otherwise.

3.4.2 Hypothesis 6: Higher levels of ownership results in larger emissions reductions

We expect that firms respond to Big Three's requests to reduce emissions when the Big Three own a large enough stake in their company. Formally, using dummy variables, we test if a larger holding size gives the Big Three more influence in reducing firm emissions.

To test this, we split Big Three holdings from Equation 1 into holding percentage intervals from [0, 1]%, [1, 2]%, …, >10%. For example, if the Big Three hold between 1% to 2% of the firm's shares, an indicator variable of 1 is assigned, and 0 otherwise. We run the model with different definitions of dependent variable such as total estimated and reported emissions, reported total emissions, Scope 1, Scope 2, Scope 3 emissions and carbon efficiency as described earlier.

$$Log(CO_2)_{it} = \alpha + \beta_1 \times Big3\_interval_{1,it-1} + \cdots + \beta_{10} \times Big3\_interval_{10,it-1} + \gamma_1 \times NonBig3\_interval_{1,it-1} + \cdots + \gamma_{10} \times NonBig3\_interval_{10,it-1} + \Phi \times Controls_{it-1} + \tau_t + \delta_i + \epsilon_{it}$$

where:

$$Big3_{interval_{1,it-1}} = 1 \text{ if } Big3_{hldg} \in [0, 1]\% \text{ and 0 otherwise}$$

$$Big3_{interval_{2,it-1}} = 1 \text{ if } Big3\_hldg \in [1, 2]\%\% \text{ and 0 otherwise}$$

…

$$Big3_{interval_{11,it-1}} = 1 \text{ if } Big3\_hldg > 10\%\% \text{ and 0 otherwise}$$

4 Data

4.1 Sample selection

We build our dataset using the sample selection process outlined in **Table 1**. We begin by obtaining the company tree structure of each of the Big Three from 2005 to 2022 and pulling the holdings of each entity in the company tree as of 10 January 2023. Next, we obtain data on each of the portfolio companies, such as total institutional investor holdings, financial, accounting and carbon data from Refinitiv. Refinitiv sources emissions data from company reports and provides estimated values when a reported value is not available. Appendix 2 outlines the methodology used by Refinitiv to estimate emission data.

Azar et al. (2021) hypothesize that the Big Three focus their engagement efforts on firms that are members of the MSCI World Index (MSCI WI), and split their sample into MSCI and non-MSCI firms. We replicate this methodology in our study using indexes obtained via two different methods. For the MSCI WI spanning 2005 to 2018, the index is reconstructed by obtaining a full list of constituents of the MSCI All Country World Index (ACWI) as of December 2020 then manually editing this list according to quarterly additions and deletions made publicly available by MSCI. The ACWI includes companies from 23 developed countries and 23 developing countries, while the MSCI WI includes only the subset of MSCI ACWI that is related to 23 developed countries. Therefore, we remove firms related to these developing countries to obtain the MSCI ACWI. We obtained this methodology and data from 2005 to 2018 from one of the original authors, and due to the resource intensiveness of this process, this methodology was not used to extend the MSCI WI beyond 2018.

Rather, for the MSCI WI spanning 2014 to 2022, we proxy the index by obtaining the constituents of iShares MSCI ACWI, an ETF that mimics the MSCI WI that is readily available from Refinitiv. We remove firms that belong to the 23 developing countries from the ACWI to obtain the WI.

We clean the raw data by filtering out missing financial and institutional ownership data, duplicate observations, NULL, NA and other erroneous data. We remove firms from our sample whose headquarters are in one of the 23 developing countries defined by the MSCI WI. We then aggregate the different holdings of each investor into a single

Table 1 Sample construction of dataset 2014 to 2022.

Steps of the sample selection procedure	# firm-years	# distinct firms
All portfolio holdings of the Big Three from Refinitiv	174,319	30,082
less observations missing institutional ownership information	150,738	27,429
less observations that do not belong to the countries covered by MSCI	74,095	12,765
less observations missing CO2, accounting, and market data	35,049	6,807
Final sample:		
MSCI constituents [Azar's in square brackets for comparison]	8,906 [19,224]	1,701 [2,104]
Other firms [Azar's in square brackets for comparison]	26,143 [22,969]	5,990 [5,647]

entry by firm and year. Our initial sample contains 217,895 firm-year observations for the sample period 2005 to 2022. We distinguish between reported and estimated data, and decompose emissions into Scope 1, 2 and 3 emissions. We remove observations with missing or negative emission data from the sample and divide the sample into firms that belong to the MSCI WI and those that do not. The final sample for the total CO_2 emission scope counts 35,049 firm-year observations, of which 8,906 correspond to firms in the MSCI WI and 26,143 observations belonging to non-constituent firms for the sample period 2014 to 2022.

We run analyses on our sample set split into two time periods: 2005 to 2018 as a pure replication of Azar et al.'s (2021) paper, and 2014 to 2022 to analyze changes post-Paris agreement.

4.2 Differences in sample data construction

While our sample covers the entire holdings of the Big Three, Azar et al. (2021) covers only mutual funds run by the Big Three. Our sample therefore includes mutual funds in addition to Exchange Traded Funds (ETF) and other investment vehicles. In addition, both of our samples may include actively managed funds. However, Fichtner et al. (2017) find that the Big Three hold over 80% of their equity Assets under Management (AUM) in passive funds.

Azar et al. (2021) gather data from a variety of data providers, including Trucost and Factset/LionShares, where we only use Refinitiv. Trucost is a widely used source of emission data used by MSCI and S&P in their indexes, and Bolton & Kacperczyk (2021) find a correlation of 0.99 among direct CO2 emissions provided by five data providers that include Trucost (Azar et al., 2021). The reliability of Refinitiv data is

not in the scope of this thesis, but it should be considered that correlation between Trucost and Refinitiv data has not been established. The use of different data providers impacts our sample, as each data provider use different models for estimating CO2 emissions.. Given that Azar et al. (2021) use total estimated and reported data as their CO2 specification, our results will deviate from theirs.

4.3 Description of variables

The main dependent variable used in the regressions is the natural logarithm of total CO_2 emissions in equivalents of metric tonnes. Refinitiv reports total CO_2 emissions as the sum of Scope 1 and Scope 2 emissions. We have defined *log_CO2tot* as the natural logarithm of the sum of Scope 1, 2 and 3 emissions, including estimated values, and *log_CO2reptot* in the same way, but with only reported values. *log_scope1*, *log_scope2* and *log_scope3* are the natural logarithms of the individual CO_2 emission scopes. *Big3_hldg* is the aggregated percentage holdings of BlackRock, State Street and Vanguard, and *NonBig3_hldg* is total percentage institutional holding minus the holdings of Big3 investors. Refinitiv returns 9,388 observations where total institutional ownership is greater than 100%. This could be the result of shorting or double counting of the securities when institutions share investment control over parts of the asset and deliver multiple filings on the same security. There could also be cases where Refinitiv have incorrect shares outstanding, or incorrect adjustment of number of shares. We treat these observations as errors, and truncate observations to maximum value of 95% and minimum value of 5%. Observations of Big Three holdings greater than 100% are treated as errors and removed.

Size is included to take into account that firms with a larger amount of assets has higher business activity and that larger firms potentially are under greater pressure from society related to environmental issues, and it is defined as the logarithm of total assets. *ROA* is the performance metric return on assets, defined as net income divided by total assets. *Log(BM),* defined as the logarithm of book value of equity divided by market value of equity, is included to as a measure of a firm's growth opportunities. *PPE* and *Leverage* measure a firm's capacity for borrowing and are defined as property, plant and equipment divided by total assets, and total debt divided by total assets respectively. A firm with a high fraction of long-term assets can provide more collateral

for borrowing, while a highly levered firm may be constrained by high outflows of cash, restricting its borrowing capacity.

4.4 Summary statistics

The descriptive statistics of our sample is presented in **Table 2**. Our sample contains lower mean *log(CO_2)* but higher standard deviation compared to Azar et al.s' (2021). The mean of Big Three holdings and *size* is larger in our sample, which indicates that our dataset has a high proportion of large firms in which Big Three hold a significant stake. The remaining control variables display similar characteristics as Azar et al.'s (2021) paper.

Table 2 Panel B shows the sample distribution across countries. Approximately a third of both subsamples comprise firms with the US as their country of headquarters. The mean of Big Three holding is largest in the US, with 20% and 15% in the MSCI and non-MSCI subsamples.

Figure 1 Emissions categorized by industry in our sample set 2014-2022. The grey columns depict the mean CO_2 of firms in each industry, and the black filled in circles represent statistically significant coefficients for which Big Three ownership is associated with total reported firm emissions at 5% significance.

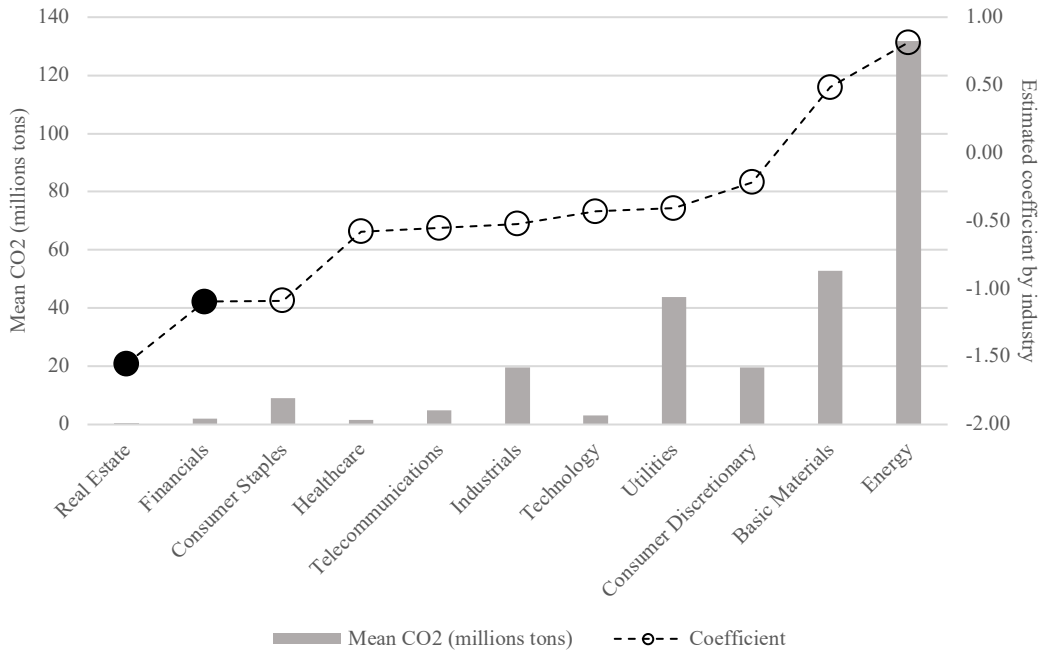


Table 2 Descriptive statistics of sample data 2014-2022. Following Azar et al. (2021) we include a set of control variables in the regression to account for different firm characteristics. All the control variables are winsorized at the 5th and 95th percentiles to reduce the effect of outliers.

Panel A. Descriptive statistics of key variables

	MSCI					Non-MSCI				
	Std dev	P25	Median	Mean	P75	Std dev	P25	Median	Mean	P75
Log(CO2)	2.85	11.59	13.37	13.57	15.64	3.00	8.38	10.46	10.54	12.49
Big3_hldg	0.075	0.048	0.096	0.114	0.178	0.082	0.019	0.045	0.079	0.119
BlackRock_hldg	0.030	0.023	0.055	0.052	0.072	0.703	0.006	0.019	0.045	0.063
StateStreet_hldg	0.023	0.002	0.005	0.020	0.041	0.138	0.001	0.002	0.011	0.016
Vanguard_hldg	0.033	0.017	0.027	0.043	0.070	0.031	0.007	0.020	0.030	0.043
NonBig3_hldg	0.199	0.258	0.416	0.421	0.594	0.227	0.199	0.381	0.393	0.586
Controls:										
Size	1.54	22.90	23.87	23.99	24.93	1.92	20.39	21.51	21.60	22.63
Log(BM)	0.99	-1.55	-0.88	-0.99	-0.30	0.99	-1.26	-0.62	-0.72	-0.11
ROA	0.06	0.01	0.04	0.05	0.08	0.10	0.00	0.02	0.01	0.06
Leverage	0.16	0.12	0.23	0.24	0.35	0.18	0.07	0.20	0.23	0.34
PPE	0.24	0.04	0.15	0.24	0.36	0.25	0.02	0.14	0.23	0.36

Panel B. Descriptive statistics of sample distribution by country

	MSCI					Non-MSCI				
	# obs.	% obs.	# firms	Mean CO2 (millions tons)	Mean Big3_hldg	# obs.	% obs.	# firms	Mean CO2 (millions tons)	Mean Big3_hldg
Australia	436	4.90	78	31.51	0.12	1723	6.59	362	3.00	0.05
Austria	36	0.40	7	38.12	0.05	183	0.70	31	1.82	0.03
Belgium	69	0.77	14	5.73	0.06	266	1.02	50	1.75	0.03
Canada	489	5.49	96	8.80	0.04	2 250	8.61	477	1.72	0.03
Denmark	113	1.27	20	6.33	0.06	246	0.94	52	1.99	0.03
Finland	75	0.84	13	17.98	0.07	288	1.10	61	4.34	0.03
France	428	4.81	68	21.66	0.07	675	2.58	137	11.31	0.03
Germany	388	4.36	69	43.46	0.09	850	3.25	195	8.57	0.04
Hong Kong	424	4.76	93	5.39	0.04	680	2.60	144	3.19	0.02
Ireland	129	1.45	24	27.06	0.16	192	0.73	42	4.85	0.06
Israel	61	0.68	14	0.90	0.05	129	0.49	32	0.49	0.02
Italy	150	1.68	27	27.49	0.06	610	2.33	141	5.90	0.02
Japan	1 506	16.91	315	15.82	0.06	2 306	8.82	410	4.81	0.04
Netherlands	140	1.57	30	39.81	0.08	368	1.41	73	2.51	0.04
New Zealand	31	0.35	9	0.21	0.08	252	0.96	46	0.71	0.03
Norway	67	0.75	13	46.15	0.04	305	1.17	74	7.87	0.02
Portugal	23	0.26	4	24.22	0.08	67	0.26	14	1.07	0.03
Singapore	112	1.26	25	1.17	0.05	290	1.11	67	1.84	0.03
Spain	145	1.63	24	22.57	0.07	393	1.50	72	3.82	0.02
Sweden	207	2.32	45	7.97	0.06	878	3.36	227	2.26	0.03
Switzerland	299	3.36	48	18.66	0.09	772	2.95	165	1.25	0.03
UK	644	7.23	110	61.20	0.12	2 522	9.65	522	15.92	0.06
USA	2 934	32.94	555	17.01	0.20	9 898	37.86	2 596	1.19	0.15

Panel C. Descriptive statistics of sample distribution by industry

	MSCI					Non-MSCI				
	# obs.	% obs.	# firms	Mean CO2 (millions tons)	Mean Big3_hldg	# obs.	% obs.	# firms	Mean CO2 (millions tons)	Mean Big3_hldg
Utilities	592	6.65	95	43.82	0.13	898	3.43	180	11.68	0.09
Real Estate	373	4.19	86	0.47	0.13	1521	5.82	359	0.33	0.09
Financials	1422	15.97	245	2.08	0.11	4872	18.64	991	0.57	0.1
Consumer Staples	730	8.2	132	8.95	0.11	1388	5.31	291	2.34	0.06
Consumer Discretionary	1262	14.17	253	19.65	0.1	4091	15.65	916	2.67	0.07
Energy	470	5.28	82	131.73	0.12	1500	5.74	349	28.69	0.06
Industrials	1580	17.74	323	19.69	0.11	4865	18.61	1047	2.38	0.08
Telecommunications	369	4.14	62	4.78	0.08	698	2.67	165	1.36	0.08
Basic Materials	613	6.88	116	52.92	0.11	2178	8.33	433	9.36	0.07
Health Care	802	9.01	152	1.48	0.13	2459	9.41	757	0.15	0.08
Technology	693	7.78	155	3.1	0.13	1673	6.4	502	0.3	0.08

Table 2 Panel C shows the sample distribution broken down by industry. We use the industry classification provided by Refinitiv, which is a less granulated classification method than that used by Azar et al. (2021). Over half of the firms in our sample belong to the Financial, Industrial and Consumer Discretionary industries in both the MSCI and non-MSCI subsets. The industries with the largest CO_2 emissions are Utilities, Energy and Basic materials, and the Big Three has a significant stake of 7% or more in companies in each of these industries. **Figure 1** shows the mean CO_2 emissions of the Big Three in our sample, categorized by industry. We overlay the emissions with coefficients of the association of the Big Three on total reported firm emissions. This figure suggests that the Big Three are associated with lower emissions in Real Estate and Financials, which have some of the lowest emissions of all industries.

5 Results & Analysis

This section presents the results of conducting a base analysis that tests whether Big Three holdings reduce firm emissions, using varying specifications of emissions such as estimated and reported, reported and Scope 1, 2 and 3 emissions. Further tests analyze whether increases in Big Three holdings are associated with increases in emission reductions, and the effect of Big Three ownership on emissions over time. We find evidence that Big Three ownership is associated with increased firm emissions in the time period 2005-2018, and reduced firm emissions in the time period spanning 2014-2022. We do not find associations between larger Big Three holdings and increased emission reductions, or increased emission reductions throughout time.

5.1 Aggregate effect of Big Three ownership in 2005-2018

In the next two sections, we compare and contrast the aggregate effect of Big Three ownership in two different time periods of pre and post-Paris agreement (with some overlap) of 2005 to 2018, and 2014 to 2022 respectively.

In our preliminary analysis, we replicate Azar et al.'s (2021) methodology using the same sample period of 2005-2018, and expand their study using different CO_2 emission specifications. To study the relationship between Big Three holdings and firm emissions, we first regress total estimated and reported emissions against *Big3_hldg* and *NonBig3_hldg*, and test the hypothesis that Big Three holdings are not associated

Table 3 Summary of Big Three ownership and different specifications of firm carbon emissions from 2005 to 2018. The sample covering total estimated and reported CO_2 emissions includes 17,834 firm-year observations in the MSCI subsample and 12,944 firm-year observations in the non-MSCI subsample. We use different specifications for CO_2, beginning with total estimated and reported emissions as a direct replication of Azar et al.'s (2021) paper. We then test the robustness of this result by removing estimated emissions. Following this, we break down total reported emissions into Scope 1, 2 and 3 emissions. *Big3_hldg*, the independent variable, is the percentage of the firm's equity owned by Blackrock, Vanguard or State Street. The regression includes *NonBig3_hldg* as an independent variable, defined as the percentage of the firms' equity owned by funds managed by institutions other than the Big Three. The control variables are as defined in Section 2. Columns (1)-(3) report results corresponding to the subsample of firms that are members of the MSCI World Index. Columns (4)-(6) report results corresponding to the subsample of firms that are not members of this index. Both subsamples span from 2014 to 2022. Intercepts are omitted. ***, **, *, and . denote significance at 0.1%, 1%, 5% and 10% respectively.

Big Three ownership and firm emissions from 2005 to 2018

	Dependent Variable: log(CO_2) with differing specifications as below					
	MSCI			**Non-MSCI**		
	(1)	**(2)**	**(3)**	**(4)**	**(5)**	**(6)**
Big3_hldg						
Results from Azar et al. (2021)						
Total Emissions (Est. & Rep.)	-3.44**	-1.69*	-1.00***	-0.76	0.66	0.46
	(-5.76)	(-2.27)	(-2.83)	(-1.09)	(1.41)	(1.60)
Results from thesis models with emissions re-specified as:						
Total Emissions (Est. & Rep.)	1.53***	1.35***	1.14***	-0.14	-0.04	-0.24
	(4.67)	(3.78)	(3.65)	(-0.53)	(-0.14)	(-0.83)
Total Emissions (Rep.)	2.42***	1.71***	0.73*	-1.62***	-1.76***	-0.65.
	(5.81)	(3.73)	(2.08)	(-3.38)	(-3.6)	(-1.73)
Scope 1	-0.22	0.9	-0.09	-1.03.	-0.6	-0.57
	(-0.43)	(1.57)	(-0.30)	(-1.85)	(-1.07)	(-1.58)
Scope 2	-0.44	0.87.	-0.50	-1.74**	-1.22*	0.35
	(-1.02)	(1.82)	(-1.58)	(-3.24)	(-2.23)	(1.04)
Scope 3	10.12***	4.80***	0.25	-1.59	-2.76*	0.04
	(10.97)	(4.73)	(0.29)	(-1.41)	(-2.43)	(0.04)
NonBig3_hldg						
Results from Azar et al. (2021)						
Total Emissions (Est. & Rep.)	-0.04	-0.12	-0.07	0.36***	0.26**	0.18**
	(-0.25)	(-0.74)	(-0.75)	(3.43)	(2.50)	(2.47)
Results from thesis models with emissions re-specified as:						
Total Emissions (Est. & Rep.)	-0.22**	-0.20**	0.28**	-0.18**	-0.18**	-0.13
	(-2.92)	(-2.69)	(3.09)	(-2.84)	(-2.82)	(-1.55)
Total Emissions (Rep.)	-0.27**	-0.24*	0.41***	0.08	0.10	0.10
	(-2.75)	(-2.39)	(3.72)	(0.77)	(0.96)	(0.85)
Scope 1	0.19	0.14	0.16	0.37**	0.37**	0.14
	(1.50)	(1.11)	(1.61)	(3.04)	(3.06)	(1.18)
Scope 2	0.03	-0.03	-0.04	0.1	0.09	0.03
	(0.23)	(-0.30)	(-0.40)	(0.87)	(0.74)	(0.30)
Scope 3	-1.33***	-1.18***	0.65*	-0.28	-0.23	-0.24*
	(-5.80)	(-5.21)	(2.30)	(-1.20)	(-0.97)	(-0.69)
Controls	Y	Y	Y	Y	Y	Y
Country FE	Y	Y	N	Y	Y	N
Industry FE	Y	Y	N	Y	Y	N
Year FE	N	Y	Y	N	Y	Y
Firm FE	N	N	Y	N	N	Y

with reduced firm emissions due to the presence of estimated and dubious Scope 3 data. Next, we remove estimated data and run the regression with only reported data to test the hypothesis that Big Three holdings are not associated with reduced firm emissions due to the continued presence of dubious Scope 3 data. The results from these are presented in **Table 3**. The effect of the Big Three and Non-Big Three are divided intoMSCI and non-MSCI firms, and we specify different fixed effects in each each column. The rows in **Table 3** specify different emission specifications.

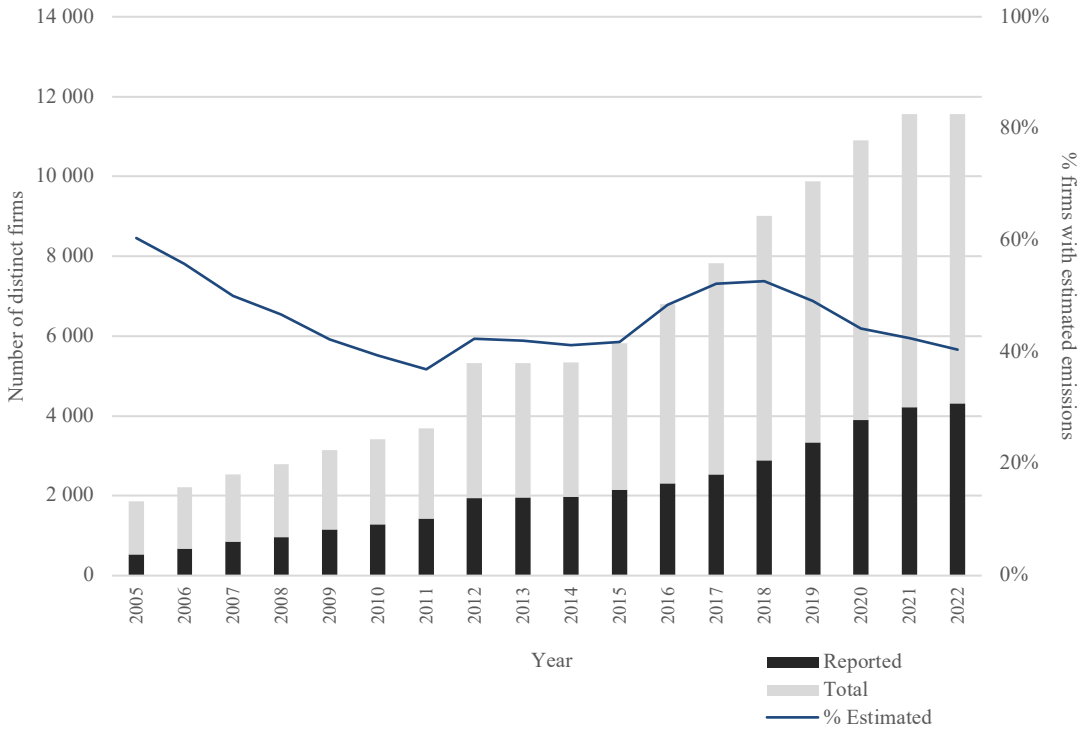
When the dependent variable is total estimated and reported emissions, we obtain coefficients ranging from 1.14** to 1.53*** depending on the fixed effect specification. Contrary to Azar et al. (2021), we find that Big Three ownership is associated with higher total estimated and reported emissions in 2005-2018. A 1 percentage point increase in Big Three ownership is associated with a 1.14% to 1.53% increase in total emissions.

When we remove estimated data, the coefficient increases to 2.42*** and 1.71** in columns (1) and (2) respectively, driven by large, statistically significant Scope 3 emissions. However, when we use firm and year fixed effects in column (3), the coefficient is smaller at 0.73*. Using this more stringent fixed effect specification suggests that Big Three holdings are still associated with an increase in total reported emissions during 2005-2018.

There are two fundamental differences that drive the discrepancy in our results. First, our sample covers all of Big Three's holdings, whereas Azar et al. (2021) covers only mutual funds. Second, we use Refinitiv vs. Trucost as data providers. Therefore, the composition of the firms in our sample is fundamentally different, and the manner in which emissions data is estimated, also diverges. To compare the differences, we present the summary data statistics for the sample period 2005-2018 in **Table 9** of the Appendices.

As an example of the differences, our control variable, *size*, is substantially larger than Azar et al.'s (2021). The mean size of firms in our sample is 23.99 versus 9.56 in Azar et al. (2021). Refinitiv reportedly covers larger firms, and to a minor extent, the larger

Figure 2 Reported versus estimated emissions by year in thesis sample set. The black columns indicate the number of unique firms that report their emission data compared to the number of unique firms that have emissions data estimated by Refinitiv, shown as gray columns,. The blue line indicates the percentage of unique firms with estimated emissions data compared to the total number of firms with estimated or reported emissions data.



values could be due to data errors from Refinitiv that repeatedly returning some asset values in local currency instead of United States dollar (USD). The implication of a larger *size* control variable is that larger firms emit more than smaller ones, and are more likely to be under stricter scrutiny and regulation. To some extent, the differences in our sample related to firm size is controlled when we run *size* as a control variable in the regressions, but there could be spillover effects of *size* that are neither captured in the control variables or fixed effects.

As another example of the differences, the Big Three have a higher mean ownership percentage in our sample of 0.114, versus 0.048 in Azar et al.s' (2021) and smaller *Log(BM)* of -0.99 vs. -0.83. In addition, the standard deviation of *Log(CO2)* in our sample, is larger at 2.85 versus 1.81, despite similar means and medians. The mean CO_2 emissions for several countries is much higher, such as Australia 31.51 vs. 4.21 and Norway 46.15 vs. 10.26.

In addition, a dataset with many observations pre-Paris agreement may be largely composed of estimated data, which is calculated differently according to different data

providers. **Figure 2** shows the extent of estimated data in our sample set, with 53%-60% of emissions data being estimated by Refinitiv in 2005-2018. We expect that analyses with a small number of firms where more than half of that data is estimated would yield less reliable empirical results.

These data discrepancies and a large proportion of estimated data point to different datasets being the driver of contrary results. Note that we do not cluster our standard errors as Azar et al. (2021) do, and this would affect the significance of our results although the value of the coefficients would be unchanged.

5.2 Aggregate effect of Big Three ownership in 2014-2022

We now extend our analysis further to consider the association between the Big Three and firm emissions post-Paris agreement. We run the same models as Azar et al. (2021) on sample data spanning 2014-2022. In the 2005-2018 analyses, we obtain a manually replicated MSCI World Index from the original authors[7] that were reconstructed from quarterly additions and deletions published by MSCI. This replication process is resource intensive, and as an imperfect alternative, we replicate the index by obtaining the constituent firms of iShares ACWI, an ETF that mimics the MSCI ACWI. We then remove firms that in developing countries to obtain the MSCI World Index (MSCI WI). The constituent list calculated at the end of the year instead of reconstructing from a list of leavers and joiners to the ETF.

Table 4 presents a summary of the results of Big Three and Non-Big Three ownership across differing CO_2 emission specifications for the sample spanning 2014 to 2022, and we now discuss the effect of different emission specifications on our findings.

5.2.1 Aggregate effect of Big Three ownership on total estimated and reported emissions

For the sub-sample of MSCI firms in column (1) and (2) in **Table 4**, we find a positive effect of *Big3_hldg* on firm emissions, which is the opposite of Azar et al.'s (2021) results. However, when we apply more stringent firm and year fixed effects in column (3), the coefficient becomes negative, in line with Azar et al.'s (2021) results. We

[7] Thanks to Igor Kadach, one of the original authors of Azar et al. (2021).

Table 4 Summary of Big Three ownership and different specifications of firm carbon emissions from 2014 to 2022. The sample covering total estimated and reported CO_2 emissions includes 8,906 firm-year observations in the MSCI subsample and 26,143 firm-year observations in the non-MSCI subsample. We use different specifications for the dependent variable representing CO_2 emissions, beginning with total estimated and reported emissions as a direct replication of Azar et al.'s (2021) paper. We then test the robustness of this result by removing estimated emissions. Following this, we break down total reported emissions into Scope 1, 2 and 3 emissions. *Big3_hldg*, the independent variable, is the percentage of the firm's equity owned by Blackrock, Vanguard or State Street. The regression includes *NonBig3_hldg* as an independent variable, defined as the percentage of the firms' equity owned by funds managed by institutions other than the Big Three. The control variables are as defined in Section 2. Columns (1)-(3) report results corresponding to the subsample of firms that are members of the MSCI World Index. Columns (4)-(6) report results corresponding to the subsample of firms that are not members of this index. Intercepts are omitted. ***, **, *, and . denote significance at 0.1%, 1%, 5% and 10% respectively.

Panel A. Big Three ownership and firm emissions from 2014 to 2022

	Dependent Variable: log(CO_2) with differing specifications as below					
	MSCI			**Non-MSCI**		
Big3_hldg	**(1)**	**(2)**	**(3)**	**(4)**	**(5)**	**(6)**
Results from Azar et al. (2021)						
Total Emissions (Est. & Rep.)	-3.44**	-1.69*	-1.00***	-0.76	0.66	0.46
	(-5.76)	(-2.27)	(-2.83)	(-1.09)	(1.41)	(1.60)
Results from thesis models with emissions re-specified as:						
Total Emissions (Est. & Rep.)	3.20***	3.03***	-1.47**	-1.09***	-0.76***	-0.49*
	(6.45)	(5.59)	(-2.72)	(-5.39)	(-3.72)	(-2.28)
Total Emissions (Rep.)	3.00***	2.59***	-1.37*	-2.54***	-2.49***	-0.51
	(5.55)	(4.41)	(-2.43)	(-6.83)	(-6.62)	(-1.33)
Scope 1	0.69	2.44***	-0.25	-2.58***	-1.69***	-0.09
	(1.29)	(4.26)	(-0.7)	(-5.97)	(-3.91)	(-0.33)
Scope 2	-0.03	2.83***	-0.37	-2.32***	-1.15**	-0.26
	(-0.06)	(5.43)	(-1.13)	(-5.68)	(-2.83)	(-0.92)
Scope 3	6.82***	5.43***	0.64	-2.4**	-3.32***	1.06
	(7.43)	(5.4)	(0.66)	(-2.94)	(-4.03)	(1.3)
Results from thesis carbon intensity specifications based on:						
Total Emissions (Est. & Rep.)	2.41***	1.62**	0.07	-0.74**	-0.93**	-0.70*
	(4.68)	(2.86)	(0.1)	(-2.6)	(-3.22)	(-1.37)
Total Emissions (Rep.)	2.33***	1.6**	0.23	-0.25.	-0.42**	-0.41
	(4.68)	(2.93)	(0.31)	(-1.7)	(-2.79)	(-1.34)
Scope 1	-0.30**	-0.28**	-0.03	0.02	0.05	-1.10*
	(-3.09)	(-2.63)	(-0.51)	(0.06)	(0.21)	(-2.00)
Scope 2	-0.02	0.02	-0.02	0.00	0.01	-0.07*
	(-1.03)	(0.77)	(-0.88)	(0.1)	(0.22)	(-2.02)
Scope 3	3.74***	3.06**	0.66	-4.33***	-5.01***	0.53
	(4.43)	(3.28)	(0.88)	(-3.59)	(-4.11)	(0.74)
Controls	Y	Y	Y	Y	Y	Y
Country FE	Y	Y	N	Y	Y	N
Industry FE	Y	Y	N	Y	Y	N
Year FE	N	Y	Y	N	Y	Y
Firm FE	N	N	Y	N	N	Y

Panel B. Non-Big Three ownership and firm emissions from 2014 to 2022

	Dependent Variable: log(CO_2) with differing specifications as below					
	MSCI			Non-MSCI		
NonBig3_hldg	(1)	(2)	(3)	(4)	(5)	(6)
Results from Azar et al. (2021)						
Total Emissions (Est. & Rep.)	-0.04	-0.12	-0.07	0.36***	0.26**	0.18**
	(-0.25)	(-0.74)	(-0.75)	(3.43)	(2.50)	(2.47)
Results from thesis models with emissions re-specified as:						
Total Emissions (Est. & Rep.)	-0.90***	-0.89***	-0.63**	-0.40***	-0.51***	0.11
	(-6.08)	(-5.92)	(-3.03)	(-7.04)	(-8.97)	(1.46)
Total Emissions (Rep.)	-1.11***	-1.07***	-0.27	-0.53***	-0.56***	0.25*
	(-6.88)	(-6.57)	(-1.26)	(-5.75)	(-6.16)	(2.12)
Scope 1	-0.38*	-0.62***	0.00	-0.28**	-0.44***	-0.13
	(-2.39)	(-3.86)	(0.01)	(-2.59)	(-4.19)	(-1.61)
Scope 2	-0.31*	-0.68***	-0.11	-0.73***	-0.94***	-0.02
	(-2.13)	(-4.69)	(-0.86)	(-7.35)	(-9.57)	(-0.27)
Scope 3	-2.54***	-2.40***	0.10	-1.10***	-1.01***	0.17
	(-9.56)	(-8.92)	(0.28)	(-5.83)	(-5.4)	(0.67)
Results from thesis carbon intensity specifications based on:						
Total Emissions (Est. & Rep.)	-0.70***	-0.61***	-0.31	-0.38***	-0.35***	-0.29.
	(-4.53)	(-3.86)	(-1.08)	(-4.79)	(-4.30)	(-1.67)
Total Emissions (Rep.)	-0.70***	-0.62***	-0.28	-0.20***	-0.19***	-0.25**
	(-4.69)	(-4.07)	(-1.01)	(-5.34)	(-4.87)	(-2.73)
Scope 1	-0.09**	-0.09**	-0.02	-0.03	-0.04	-0.07
	(-2.97)	(-3.04)	(-0.85)	(-0.59)	(-0.75)	(-0.39)
Scope 2	0.00	-0.01	0.00	-0.02*	-0.03*	-0.01
	(-0.51)	(-1.34)	(-0.03)	(-2.17)	(-2.26)	(-0.56)
Scope 3	-0.77**	-0.70**	0.00	-0.55*	-0.49.	0.49*
	(-3.13)	(-2.82)	(0.01)	(-1.99)	(-1.75)	(2.15)
Controls	Y	Y	Y	Y	Y	Y
Country FE	Y	Y	N	Y	Y	N
Industry FE	Y	Y	N	Y	Y	N
Year FE	N	Y	Y	N	Y	Y
Firm FE	N	N	Y	N	N	Y

believe there are firm specific variations that are incorrectly attributed to the Big Three in column (1) and (2). For example, in column (1), the introduction of mandatory carbon reporting would be captured in year fixed affects but not in an industry and country fixed effects model.

This would affect the results by making it appear that emissions have increased when no physical emissions increase has actually occurred as in the case of (1). This is due to the change from estimated to reported emissions. When Refinitiv estimates emissions using industry averages or industry peer values in their calculations, these estimated values are likely to be underestimated, as firms that report voluntarily typically have lower than industry level emissions. When firms are forced to report under new mandatory reporting guidelines, their emissions data changes from underestimated industry averages to actual emissions data. The introduction of mandatory reporting, a different carbon accounting framework and other time variant

variables could cause an increase in firm emissions that is unrelated to the Big Three's actions on emissions. This results in these effects being attributed to the Big Three in column (1).

In column (2), we control for the effects of the introduction of mandatory reporting in by including year fixed effects to the current country and year fixed effects. However, we still observe a positive coefficient for total emissions, driven by positive and significant coefficients for Scope 1, 2, and 3. While we capture variability from time variant variables in column (2), we still do not account for firm specific actions such as voluntary reporting to stay ahead of mandatory regulations. Large, well-organized firms typically do not wait until the introduction of mandatory reporting to implement carbon reporting. Instead, they are proactive to competitors, regulations or customers' demands, and implement carbon accounting and reporting voluntarily.

We observe large and significant coefficients for Scope 1 and 2 emissions, but a moderate decrease for the Scope 3 emissions coefficient compared to its value in column (1). We believe that this corresponds to the way net zero pledges are structured. When a firm pledges to be net zero or Paris Agreement compliant by a certain year, they pledge to decrease their Scope 1 and 2 emissions only. This pledge does not cover Scope 3 emissions. Therefore, when a firm starts to report voluntarily in connection to meeting their net zero pledge , their Scope 1 and 2 emissions data can appear to increase from an underestimated industry level to actual emissions.

In column (3), we remove firm and year variability, which encompass a broader set of omitted variables including industry, country, year and firm effects. When the effect of voluntary and mandatory reporting, and potentially other firm specific omitted variables are included in this model, the coefficient becomes negative and remains significant. A coefficient of -1.47*** indicates that a 1 percentage point increase in the fraction of shares held by Big Three is associated with 1.47% lower firm carbon emissions.

Therefore, we reject Hypothesis 1A that Big Three ownership is associated with positive firm emissions. Interestingly, in tests done on earlier data from 2005-2018, we did not find a significant relationship between Big Three ownership and a reduction in total firm emissions for non-MSCI firms. However, when updating our results with

2014-2022 data, we observe not just a negative relationship between MSCI firm emissions, but also between non-MSCI emissions. This could indicate that the Big Three are expanding their efforts on climate change to smaller firms.

Similarly, post-Paris Agreement, we observe that the coefficient of *NonBig3_hldg* is negative, where it was not significant in earlier samples from both our and Azar et al.'s (2021) analysis.

5.2.2 Effect of removing estimated data

A weakness of Azar et al.'s (2021) paper is the inclusion of estimated data in their sample set. To address this, we remove estimated data from our sample set, and test whether their findings still hold. The results are summarized in **Table 4**. We continue to find a negative, but statistically weaker relationship between Big Three holdings and total reported emissions for MSCI firms in column (3). Therefore, we reject Hypothesis 1B that the Big Three do not reduce MSCI firm emissions when estimated emissions are removed.

For non-MSCI firms, we find that the Big Three no longer have a significant effect on total emissions when estimated data is removed, where it was previously negative and weakly significant when estimated data was included. Unfortunately, our previous belief that the Big Three could be expanding their engagement efforts to smaller, non-MSCI firms does not hold true when estimated data is removed. This highlights the importance of mandatory reporting measures such as Corporate Sustainability Reporting Directive (CSRD), which came into effect in the EU in January 2023.

Overall, the original question of "whether changes in firm emissions are a result of meaningful decarbonization efforts by a firm, or simply changes in reporting, either by data providers or firms themselves" can be answered thus: Azar et al. (2021) found that higher levels of Big 3 ownership are associated with lower total estimated and reported MSCI, and we find the same association when estimated data is removed, but at a much weaker significance level of 10%.

5.2.3 Effect of Big Three holdings on Scope 1, 2 and 3 emissions

We decompose reported CO_2 emissions by Scope, but do not find consistent evidence across columns (1) and (3) that the Big Three are associated with Scope specific emissions reductions.

5.2.4 Effect of Big Three holdings on carbon intensity

As a complement to total emissions specifications, we use carbon intensity as a comparative measure of a firm's emissions relative to its sales. We find that Big Three holdings are associated with improved Scope 1 and 2 carbon intensity of non-MSCI firms but not total emissions of MSCI or non-MSCI firms. These findings are contrary to our findings using absolute emission measures.

Carbon intensity based on revenue does not account for factors such as volatile commodity prices or high-end companies that have larger revenues due to higher markups. However, attempting to address these deficiencies introduces new problems. For example, addressing volatile commodity prices by using a carbon intensity measure based on units sold are suitable for firms that sell products, not services. Addressing measurement errors introduced by firms with high markups using cost of goods sold (COGS) is also more suited for product-based firms. We recommend further work on a carbon intensity measure that takes these limitations into consideration and is realistic to implement.

5.3 Effect of individual Big Three investors on firm emissions

We now decompose *Big3_hldg* into its individual components *BlackRock_hldg, StateStreet_hldg* and *Vanguard_hldg,* to analyze the association of each investor with firm emissions. We apply firm and year fixed effects and report the results in **Table 7**.

Azar et al. (2021) find that Blackrock, and to a weaker extent, State Street are the two institutional owners driving emissions reductions of MSCI firms in 2005-2018. Vanguard and other institutional owners are not associated with any effect on firm emissions.

Using 2014-2022 data, we find in **Table 7** that only Vanguard is associated with negative total reported emissions for both MSCI and non-MSCI firms. This result is

Table 5 Breakdown of ownership. This table repeats the analysis in **Table 4**, breaking down the variable *Big3_hldg* into individual investor holdings. The sample spans from 2014 to 2022 and the sample covering total estimated and reported CO_2 emissions includes 8,965 firm-year observations in the MSCI subsample and 26,430 firm-year observations in the non-MSCI subsample. We use different specifications for the dependent variable representing CO_2 emissions, beginning with total estimated and reported emissions as a direct replication of Azar et al.'s (2021) paper. We then test the robustness of this result by removing estimated emissions. Following this, we break down total reported emissions into Scope 1, 2 and 3 emissions. *Blackrock_hldg*, *Vanguard_hldg* and *Statestreet_hldg* are the fraction of the firm's equity owned by Blackrock, Vanguard or State Street respectively. Intercepts are omitted. ***, **, *, and . denote significance at 0.1%, 1%, 5% and 10% respectively.

Panel A: Blackrock and State Street ownership and firm emissions

	Dependent Variable: log(CO_2) with specifications as below	
	MSCI	Non-MSCI
	(1)	(2)
Blackrock_hldg		
Results from Azar et al. (2021)		
Total Emissions (Est. & Rep.)	-2.79*	-0.21
	(-5.27)	(-0.49)
Results from thesis models with emissions re-specified as:		
Total Emissions (Est. & Rep.)	-1.10	-0.23
	(-1.48)	(-0.68)
Total Emissions (Rep.)	-0.5	-0.18
	(-0.68)	(-0.38)
Scope 1	-0.01	-0.29
	(-0.01)	(-0.85)
Scope 2	-0.26	-0.45
	(-0.6)	(-1.26)
Scope 3	1.01	0.82
	(0.80)	(0.82)
Results from thesis carbon intensity specifications based on:		
Total Emissions (Est. & Rep.)	-0.40	0.18
	(-0.39)	(0.22)
Total Emissions (Rep.)	-0.37	0.16
	(-0.38)	(0.31)
Scope 1	0.11	-1.06
	(1.36)	(-1.51)
Scope 2	0	-0.04
	(0.05)	(-1.05)
Scope 3	-0.08	1.21
	(-0.08)	(1.35)
Statestreet_hldg		
Results from Azar et al. (2021)		
Total Emissions (Est. & Rep.)	-2.45*	-0.84
	(-1.94)	(-0.64)
Results from thesis models with emissions re-specified as:		
Total Emissions (Est. & Rep.)	-2.50	0.93
	(-1.26)	(0.90)
Total Emissions (Rep.)	-2.76	3.18.
	(-1.35)	(1.82)
Scope 1	1.21	1.75
	(0.93)	(1.46)
Scope 2	1.58	3.19*
	(1.33)	(2.42)
Scope 3	3.91	3.62
	(1.15)	(1.01)
Results from thesis carbon intensity specifications based on:		
Total Emissions (Est. & Rep.)	3.01	-2.00
	(1.57)	(-1.31)
Total Emissions (Rep.)	3.29.	-1.00
	(1.77)	(-1.09)
Scope 1	-0.67***	-2.82.
	(-4.33)	(-1.68)
Scope 2	-0.12.	-0.21*
	(-1.82)	(-2.02)
Scope 3	-2.05	-2.65
	(-0.97)	(-1.18)
Controls	Y	Y
Year FE	Y	Y
Firm FE	Y	Y

Panel B: Vanguard and Non-Big Three ownership and firm emissions

	Dependent Variable: log(CO_2) with specifications as below	
	MSCI	Non-MSCI
	(1)	(2)
Vanguard_hldg		
Results from Azar et al. (2021)		
Total Emissions (Est. & Rep.)	0.62	2.00**
	(1.13)	(3.26)
Results from thesis models with emissions re-specified as:		
Total Emissions (Est. & Rep.)	-1.45	-1.75**
	(-1.06)	(-2.71)
Total Emissions (Rep.)	-2.74.	-3.38**
	(-1.86)	(-2.95)
Scope 1	-1.86*	-0.04
	(-1.99)	(-0.05)
Scope 2	-1.9*	-1.11
	(-2.22)	(-1.28)
Scope 3	-2.61	0.73
	(-0.97)	(0.28)
Results from thesis carbon intensity specifications based on:		
Total Emissions (Est. & Rep.)	3.01	-2.00
	(1.57)	(-1.31)
Total Emissions (Rep.)	3.29.	-1.00
	(1.77)	(-1.09)
Scope 1	-0.67***	-2.82.
	(-4.33)	(-1.68)
Scope 2	-0.12.	-0.21*
	(-1.82)	(-2.02)
Scope 3	-2.05	-2.65
	(-0.97)	(-1.18)
NonBig3_hldg		
Results from Azar et al. (2021)		
Total Emissions (Est. & Rep.)	-0.05	0.18*
	(-0.57)	(2.48)
Results from thesis models with emissions re-specified as:		
Total Emissions (Est. & Rep.)	-0.62**	0.11
	(-2.98)	(1.45)
Total Emissions (Rep.)	-0.30	0.22.
	(-1.39)	(1.94)
Scope 1	-0.03	-0.12
	(-0.19)	(-1.42)
Scope 2	-0.14	-0.02
	(-1.09)	(-0.24)
Scope 3	0.03	0.15
	(0.07)	(0.61)
Results from thesis carbon intensity specifications based on:		
Total Emissions (Est. & Rep.)	-0.24	-0.31.
	(-0.84)	(-1.82)
Total Emissions (Rep.)	-0.22	-0.25**
	(-0.8)	(-2.81)
Scope 1	-0.03	-0.07
	(-1.3)	(-0.38)
Scope 2	0.00	-0.01
	(-0.13)	(-0.51)
Scope 3	-0.09	0.43.
	(-0.33)	(1.93)
Controls	Y	Y
Year FE	Y	Y
Firm FE	Y	Y

quite surprising given Vanguard's exit from the Net Zero Asset Management initiative in late 2022, an event that are is not captured in our sample period.

5.4 Effect of Big Three ownership on firm emissions over time

We now examine the association of Big Three holdings on emissions across time in the next two sections. In this section, we plot the coefficients for each sample year, and in the next section we examine the effect of changes in Big Three ownership on changes in emissions different periods in the future. This gives us a more expansive picture of the association of Big Three ownership on emissions than a single, aggregated coefficient. We estimate Equation 1 by year and plot the coefficients in annual cross-sectional regressions in **Figure 1**. In this model, we use only firm fixed effects.

Azar et al. (2021) find that the association between Big Three ownership and total estimated and reported carbon emissions from MSCI firms becomes negative and significant after the Paris Agreement in their 2005-2018 analysis. We do not find a similar, statistically significant pattern when we use a total carbon emission specification that includes estimated data in 2014-2022. However, we do find negative coefficients in 2018 and 2019 when this estimated data is excluded.

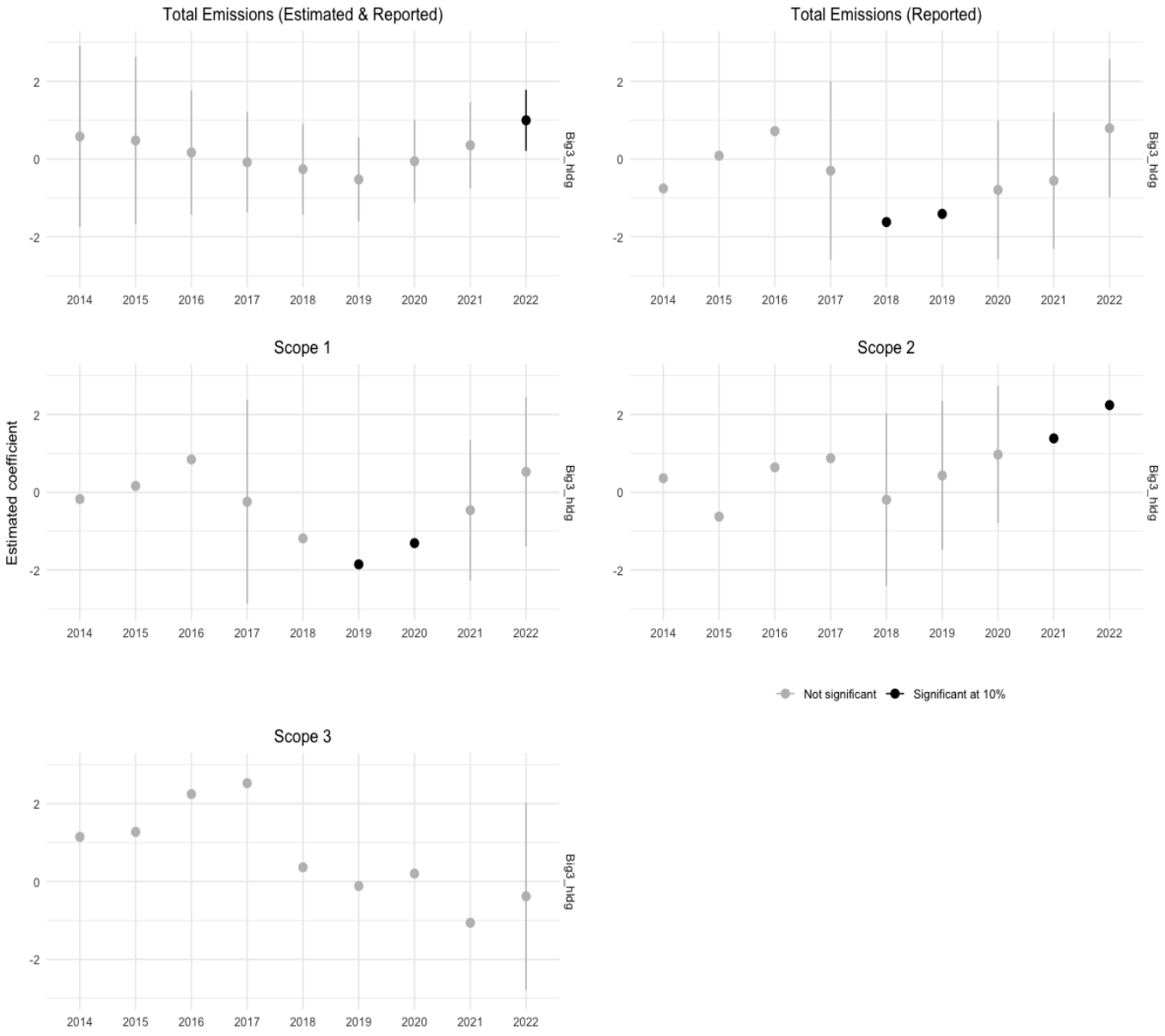
We theorize that our findings differ from Azar et al.s' (2021) due to differences in our datasets, in particular, the inclusion of estimated data in their sample that introduces patterns that may be picked up in Azar et al.'s (2021) results.

In **Figure 1** Panel C, we examine the association between Non-Big Three ownership and MSCI firm emissions over time. By only considering our results in **Table 4**, we could conclude that with a non-statistically significant coefficient of -0.27, Non-Big Three holdings are not associated with reduced emissions. This finding would be further cemented by a time series of coefficients based on total estimated and reported data, which reveals that there is no statistically significant association between Non-Big Three ownership and MSCI firm emissions. However, removing estimated data reveals negative, statistically significant coefficients that indicate that Non-Big Three holdings are associated with reduced total firm emissions over the time period 2014-2018.

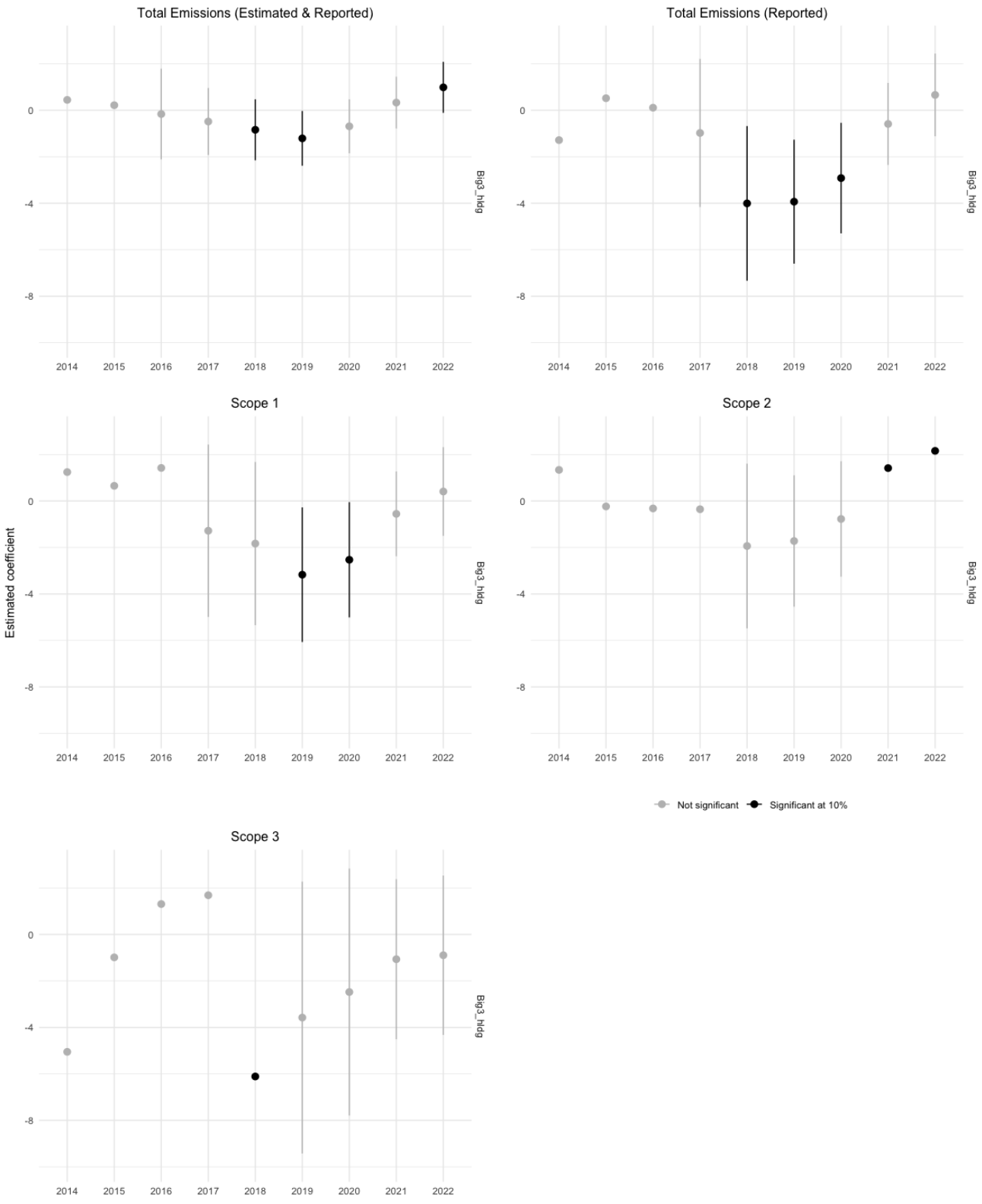
Similarly, there are negative associations between Non-Big Three ownership and the emissions of non-MSCI firms across most of the years in **Figure 1** Panel D when estimated data is used in total emissions. Removing estimated data still indicates a negative association, but in fewer years of the sample period.

Figure 3 Big Three ownership of MSCI firms and carbon emissions by year, broken down by emission scopes. This figure illustrates the association between Big Three ownership and firms' CO_2 emissions over time. The sample spans from 2014 to 2022 and includes 8,906 firm-year observations in the MSCI subsample and 26,143 firm-year observations in the non-MSCI subsample. We use different specifications for the dependent variable representing CO_2 emissions, beginning with total estimated and reported emissions as a direct replication of Azar et al.'s (2021) paper. We then test the robustness of this result by removing estimated emissions. Following this, we break down total reported emissions into Scope 1, 2 and 3 emissions. *Big3_hldg* is the fraction of the firm's equity owned by all investment vehicles sponsored by Blackrock, Vanguard or State Street. Industry and country fixed effects are used. Significance level is 10%, and the vertical lines indicate 99% confidence intervals.

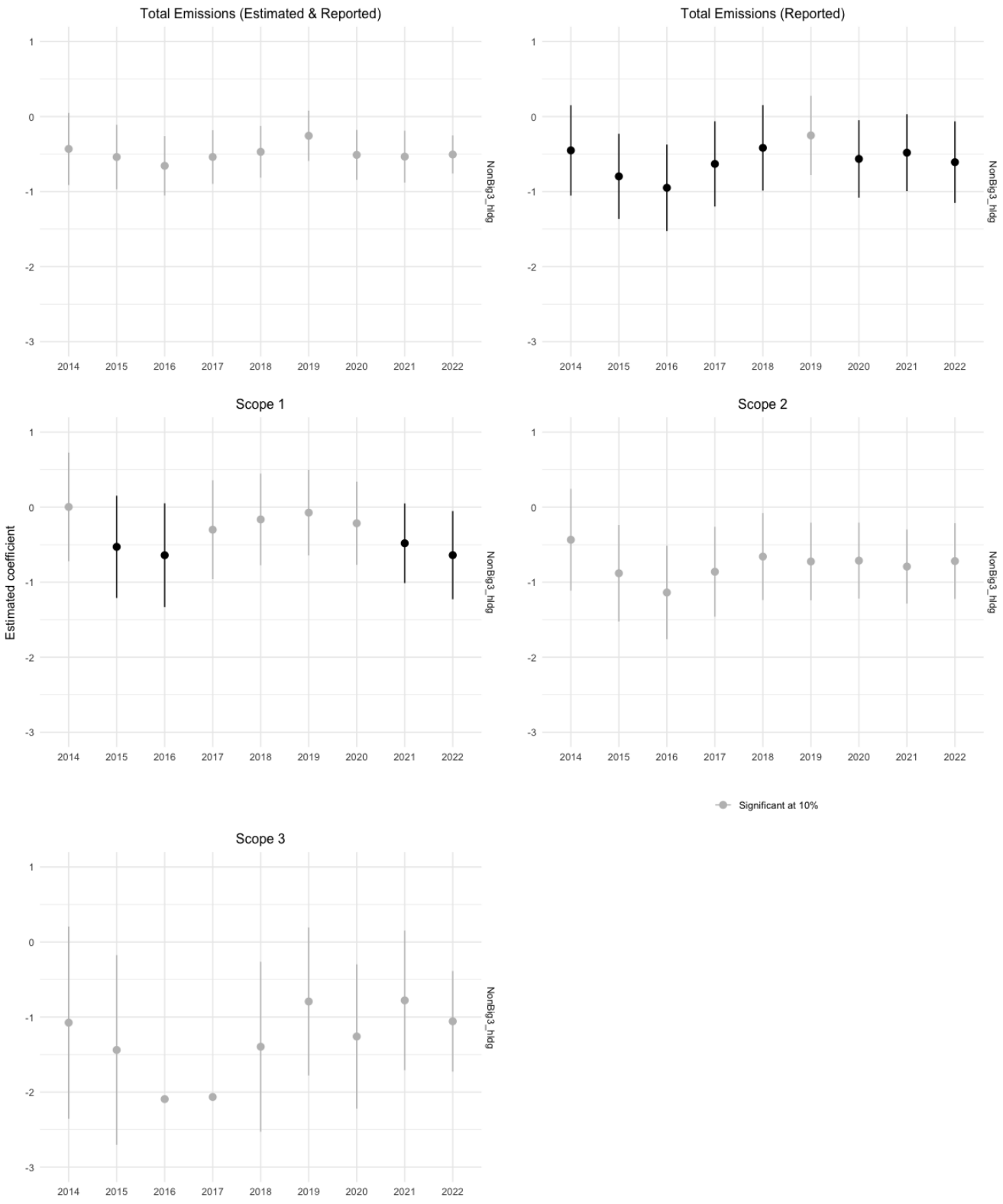
Panel A. Association between Big Three ownership and MSCI firm emissions over time



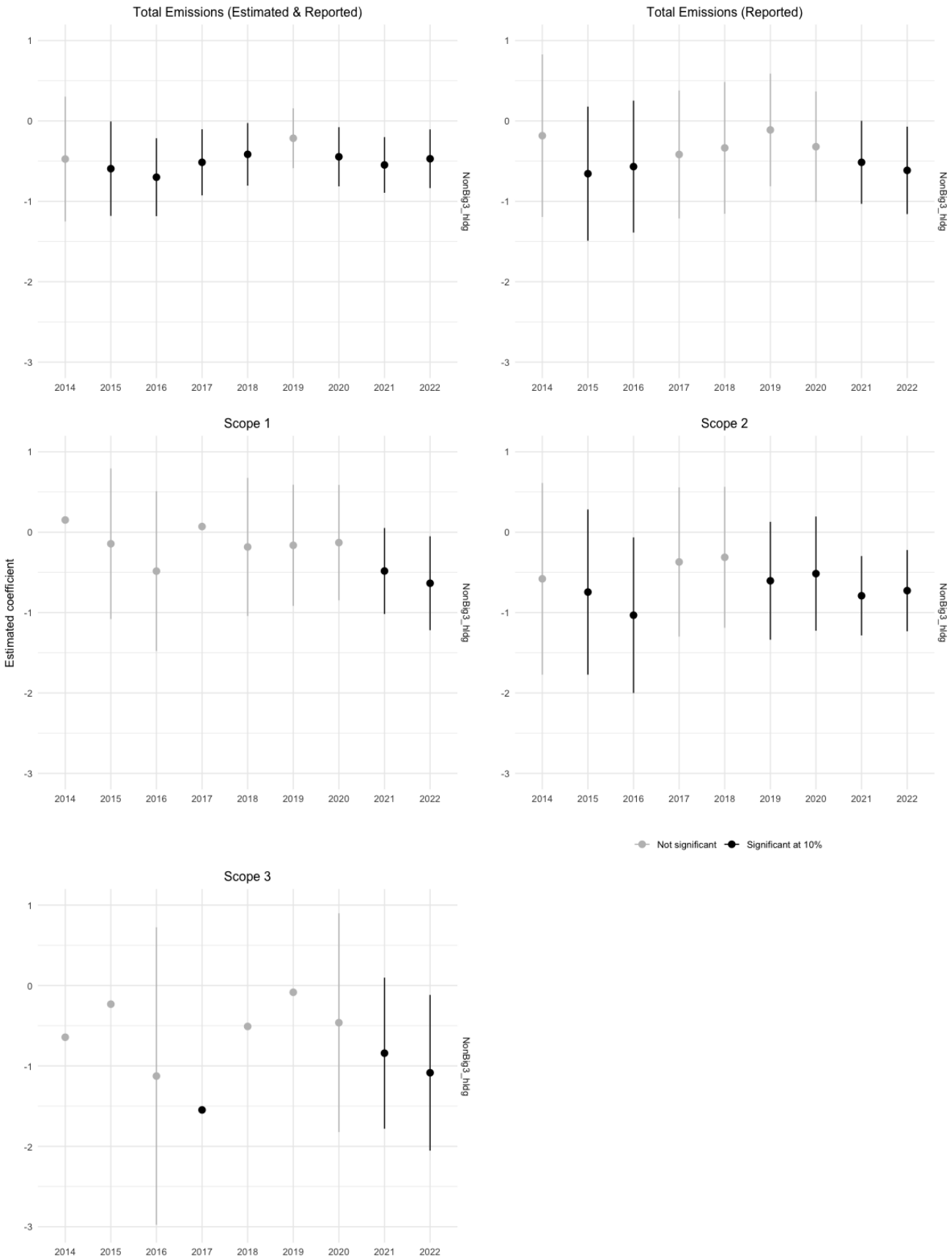
Panel B. Association between Big Three ownership and non-MSCI firm emissions over time



Panel C. Association between Non-Big Three ownership and MSCI firm emissions over time



Panel D. Association between Non-Big Three ownership and non-MSCI firm emissions over time



5.5 Effect of changes in Big Three ownership on changes in firm emissions over time

We continue exploring the association of Big Three ownership across time by analyzing changes in CO_2 emissions and changes in Big Three ownership for MSCI firms. The dependent variable is *Δ_CO₂ (t-s, t)* defined as the percentage change in CO_2 emissions from year *t-s* to year *t*. *Δ_Big3_hldg (t-s-1, t-1)* and *Δ_NonBig3_hldg (t-s-1, t-1)* is the change in *Big3_hldg* and *NonBig3_hldg* from year *t-s-1* to year *t-1* respectively. This model seeks to identify the persistence of the association between Big Three engagement or voting to later years, as their actions may take time for management to implement and take effect. For example, a decrease in emissions in year 2022 could have been the result of Big Three engagement, proxied by ownership, in 2019.

The results of **Table 6** show that unlike Azar et al. (2021), we do not find that changes in Big Three ownership are associated with subsequent changes in carbon emissions for MSCI and non-MSCI firms. We believe this is linked to the issue of estimated data again (discussed in Section 5.4) in Azar et al.'s (2021) dataset that causes biased results that persist through time. Therefore, we reject Hypothesis 4 that the effectiveness of the Big Three in reducing emissions increases over time as their holding size and influence increases.

Table 6 Changes in ownership vs. changes in firm emissions over time. In this analysis, the dependent variable is *Δ_* CO_2 *(t-s, t)* defined as the fractional change in total estimated and reported CO_2 emissions from year t-s to year t. Regressions on different specifications of emissions yield similar, non-significant results, and are not included in this table. *Δ_Big3_hldg (t-s-1, t-1*) and *Δ_NonBig3_hldg (t-s-1, t-1)* is the change in *Big3_hldg* and *NonBig3_hldg* from year *t-s-1* to year *t-1* respectively. The sample spans from 2014 to 2022 and includes 8,965 firm-year observations in the MSCI subsample and 26,430 in the non-MSCI subsample. The dependent variable is the logarithm of CO_2 (i.e. the firm's total GHG emissions measured in equivalents of tonnes of CO_2e). We use different specifications for CO_2, beginning with total estimated and reported emissions as a direct replication of Azar et al.'s (2021) paper. We then test the robustness of this result by removing estimated emissions. Following this, we break down total reported emissions into Scope 1, 2 and 3 emissions. Intercepts are omitted and standard errors are not clustered. ***, **, * and . denote significance at 0.1%, 1%, 5% and 10% respectively.

Panel A: Specification in changes (MSCI firms)

	Dependent Variable: *Δ_*CO_2 (t-s, t)					
	(1)	**(2)**	**(3)**	**(4)**	**(5)**	**(6)**
	s = 1	**s = 2**	**s = 3**	**s = 4**	**s = 5**	**s = 6**
Results from Azar et al. (2021)						
Δ_Big3_hldg (t-s-1, t-1)	-0.78*	-1.42.	-2.68*	-4.07*	-3.81.	-5.14*
	(-2.08)	(-1.82)	(-2.16)	(-2.18)	(-1.76)	(-2.11)
Δ_NonBig3_hldg (t-s-1, t-1)	0.20*	0.07	-0.34	-0.13	-0.65*	-1.48
	(2.17)	(0.44)	(-0.73)	(-0.53)	(-2.02)	(-1.58)
Results using total estimated and reported emissions 2014-2022						
Δ_Big3_hldg (t-s-1, t-1)	-0.04	-0.02	0.04	0.04	-0.02	0.57
	(-0.28)	(-0.1)	(0.2)	(0.10)	(-0.05)	(0.25)
Δ_NonBig3_hldg (t-s-1, t-1)	-2.28	-3.14	-3.33	-4.33	-3.13	-1.28
	(-0.51)	(-0.76)	(-0.84)	(-0.41)	(-0.34)	(-0.15)
Controls	Y	Y	Y	Y	Y	Y
Firm FE	Y	Y	Y	Y	Y	Y

Panel B: Specification in changes (Non-MSCI firms)

	Dependent Variable: *Δ_*CO_2 (t-s, t)					
	(1)	**(2)**	**(3)**	**(4)**	**(5)**	**(6)**
	s = 1	**s = 2**	**s = 3**	**s = 4**	**s = 5**	**s = 6**
Results from Azar et al. (2021)						
Δ_Big3_hldg (t-s-1, t-1)	1.31	1.46	1.81	1.00	5.51	4.83
	(1.20)	(0.87)	(1.06)	(0.90)	(1.04)	(1.06)
Δ_NonBig3_hldg (t-s-1, t-1)	0.93.	1.51*	0.75	1.40	1.96	1.20
	(1.75)	(2.23)	(1.52)	(1.14)	(1.11)	(0.89)
Results using total estimated and reported emissions 2014-2022						
Δ_Big3_hldg (t-s-1, t-1)	0.07***	0.00	0.00	0.00	0.00	0.00
	(3.95)	(-0.22)	(0.01)	(-0.26)	(-0.11)	(0.02)
Δ_NonBig3_hldg (t-s-1, t-1)	4.94	5.13**	0.86	-0.22	1.97	1.90
	(0.70)	(2.68)	(0.29)	(-0.06)	(0.42)	(0.09)
Controls	Y	Y	Y	Y	Y	Y
Firm FE	Y	Y	Y	Y	Y	Y

5.6 Effect of non-negligible changes in Big Three ownership on firm emissions

We now turn to analyzing the effect of larger Big Three holdings on emissions in the two next sections. In this section, we analyze the association between a meaningful increase in Big Three holdings and firm emissions. In the next section, we analyze if larger holding sizes are associated with larger emission reductions.

To gauge whether a meaningful increase in Big Three holdings leads to emission reductions, we introduce a variation of the analysis presented in **Table 4**, where we examine changes instead of absolute levels of Big Three ownership. We substitute *Big3_hldg* with a new variable, *Big3_increase,* an indicator variable that equals one if the change in Big Three ownership, *Δ_Big3_hldg*, exceeds 1%, and zero otherwise.

In **Table 5**, we observe that the coefficient of *Big3_increase* is not statistically significant for MSCI and non-MSCI firms in column (3). Therefore, we reject Hypothesis 3 that non-negligible changes in Big Three ownership result in reduced total firm emissions. However, we find that *NonBig3_increase* is weakly associated with total emissions reductions of non-MSCI firms in column (6).

Table 7 Non-negligible changes in Big Three ownership. We repeat **Error! Reference source not found.** using changes in ownership instead of levels. *Big3_hldg* is replaced with *Big3_incr*, an indicator variable that equals one if *Δ_Big3_hldg* > 1% and zero otherwise. *NonBig3_incr* is defined as one if *Δ_NonBig3_hldg* > 1% and zero otherwise. Panel A presents the results for *Big3_incr*, and the results for *NonBig3_incr* are shown in Panel B. The sample spans from 2014 to 2022 and includes 8,827 firm-year observations in the MSCI subsample and 24,930 firm-year observations in the non-MSCI subsample. We use different specifications for the dependent variable representing CO_2 emissions, beginning with total estimated and reported emissions as a direct replication of Azar et al.'s (2021) paper. We then test the robustness of this result by removing estimated emissions. Following this, we break down total reported emissions into Scope 1, 2 and 3 emissions. Intercepts are omitted. ***, **, * and . denote significance at 0.1%, 1%, 5% and 10% respectively.

Panel A. Effect of non-negligible changes in Big Three ownership on emissions

	Dependent Variable: log(CO_2) with differing specifications as below					
	MSCI			**Non-MSCI**		
Big3_increase	**(1)**	**(2)**	**(3)**	**(4)**	**(5)**	**(6)**
Results from Azar et al. (2021)						
Total Emissions (Est. & Rep.)	-0.10**	-0.04*	-0.02**	-0.05.	-0.02	0.00
	(-4.49)	(-2.52)	(-3.97)	(-1.65)	(-0.63)	(0.33)
Results from thesis models with emissions re-specified as:						
Total Emissions (Est. & Rep.)	-0.06	-0.05	-0.03	-0.01	-0.07**	-0.01
	(-1.48)	(-1.06)	(-1.19)	(-0.29)	(-2.93)	(-0.37)
Total Emissions (Rep.)	-0.04	-0.01	-0.01	-0.09*	-0.12**	-0.03
	(-0.82)	(-0.29)	(-0.31)	(-2.36)	(-3.04)	(-1.33)
Scope 1	0.02	-0.05	-0.01	-0.04	-0.12**	-0.01
	(0.54)	(-1.1)	(-0.38)	(-0.83)	(-2.62)	(-0.54)
Scope 2	0.06	-0.04	0.01	-0.03	-0.13**	-0.03.
	(1.50)	(-0.92)	(0.54)	(-0.64)	(-2.89)	(-1.67)
Scope 3	-0.10	-0.03	0.05	-0.20*	-0.16.	-0.05
	(-1.35)	(-0.34)	(1.36)	(-2.43)	(-1.94)	(-1.11)
Results from thesis carbon intensity specifications based on:						
Total Emissions (Est. & Rep.)	0.02	0.05	0.03	-0.09**	-0.09*	-0.03
	(0.39)	(1.16)	(0.9)	(-2.68)	(-2.43)	(-0.8)
Total Emissions (Rep.)	0.03	0.06	0.04	-0.05**	-0.05*	-0.02
	(0.65)	(1.38)	(1.29)	(-2.62)	(-2.53)	(-1.05)
Scope 1	0.01	0.01	0.00	0.04	0.02	0.02
	(1.63)	(1.42)	(1.04)	(1.41)	(0.68)	(0.74)
Scope 2	0.00*	0.00	0.00	-0.01.	-0.01*	0.00
	(1.98)	(1.11)	(0.83)	(-1.76)	(-1.96)	(-0.33)
Scope 3	0.01	0.04	0.01	-0.28*	-0.26*	-0.01
	(0.13)	(0.55)	(0.38)	(-2.24)	(-2.03)	(-0.31)
Controls	Y	Y	Y	Y	Y	Y
Country FE	Y	Y	N	Y	Y	N
Industry FE	Y	Y	N	Y	Y	N
Year FE	N	Y	Y	N	Y	Y
Firm FE	N	N	Y	N	N	Y

Panel B. Effect of non-negligible changes in Non-Big Three ownership on emissions

	Dependent Variable: log(CO_2) with specifications as below					
	MSCI			Non-MSCI		
NonBig3_increase	**(1)**	**(2)**	**(3)**	**(4)**	**(5)**	**(6)**
Results from Azar et al. (2021)						
Total Emissions (Est. & Rep.)	-0.02	-0.04.	-0.01.	-0.02	-0.03.	0.00
	(-0.65)	(-2.05)	(-1.93)	(-1.45)	(-2.09)	(0.50)
Results from thesis models with emissions re-specified as:						
Total Emissions (Est. & Rep.)	-0.04	-0.01	-0.01	0.00	-0.02	-0.02.
	(-0.91)	(-0.28)	(-0.5)	(0.00)	(-0.71)	(-1.8)
Total Emissions (Rep.)	-0.04	-0.01	0.00	0.00	0.00	-0.03.
	(-0.92)	(-0.28)	(-0.10)	(0.14)	(0.13)	(-1.77)
Scope 1	-0.03	-0.04	-0.02	0.11**	0.06	-0.01
	(-0.62)	(-0.9)	(-1.38)	(2.74)	(1.52)	(-1.22)
Scope 2	0.02	0.00	0.00	0.06.	0.00	-0.01
	(0.59)	(-0.08)	(0.22)	(1.71)	(0.05)	(-0.76)
Scope 3	-0.09	-0.05	-0.01	-0.12.	-0.06	-0.02
	(-1.34)	(-0.65)	(-0.16)	(-1.76)	(-0.91)	(-0.65)
Results from thesis carbon intensity specifications based on:						
Total Emissions (Est. & Rep.)	-0.02	0.00	0.02	-0.02	-0.01	0.02
	(-0.43)	(0.07)	(0.74)	(-0.78)	(-0.4)	(0.63)
Total Emissions (Rep.)	-0.02	0.00	0.02	-0.01	0.00	0.00
	(-0.49)	(-0.01)	(0.65)	(-0.92)	(-0.22)	(0.33)
Scope 1	0.01	0.01	0.01*	0.04	0.04	0.03
	(1.00)	(0.9)	(2.16)	(1.63)	(1.63)	(1.19)
Scope 2	0.00	0.00	0.00	0.00	0.00	0.00
	(1.43)	(1.14)	(1.4)	(0.74)	(0.7)	(0.59)
Scope 3	-0.03	-0.01	0.00	-0.04	-0.01	0.07*
	(-0.50)	(-0.14)	(0.14)	(-0.41)	(-0.14)	(2.05)
Controls	Y	Y	Y	Y	Y	Y
Country FE	Y	Y	N	Y	Y	N
Industry FE	Y	Y	N	Y	Y	N
Year FE	N	Y	Y	N	Y	Y
Firm FE	N	N	Y	N	N	Y

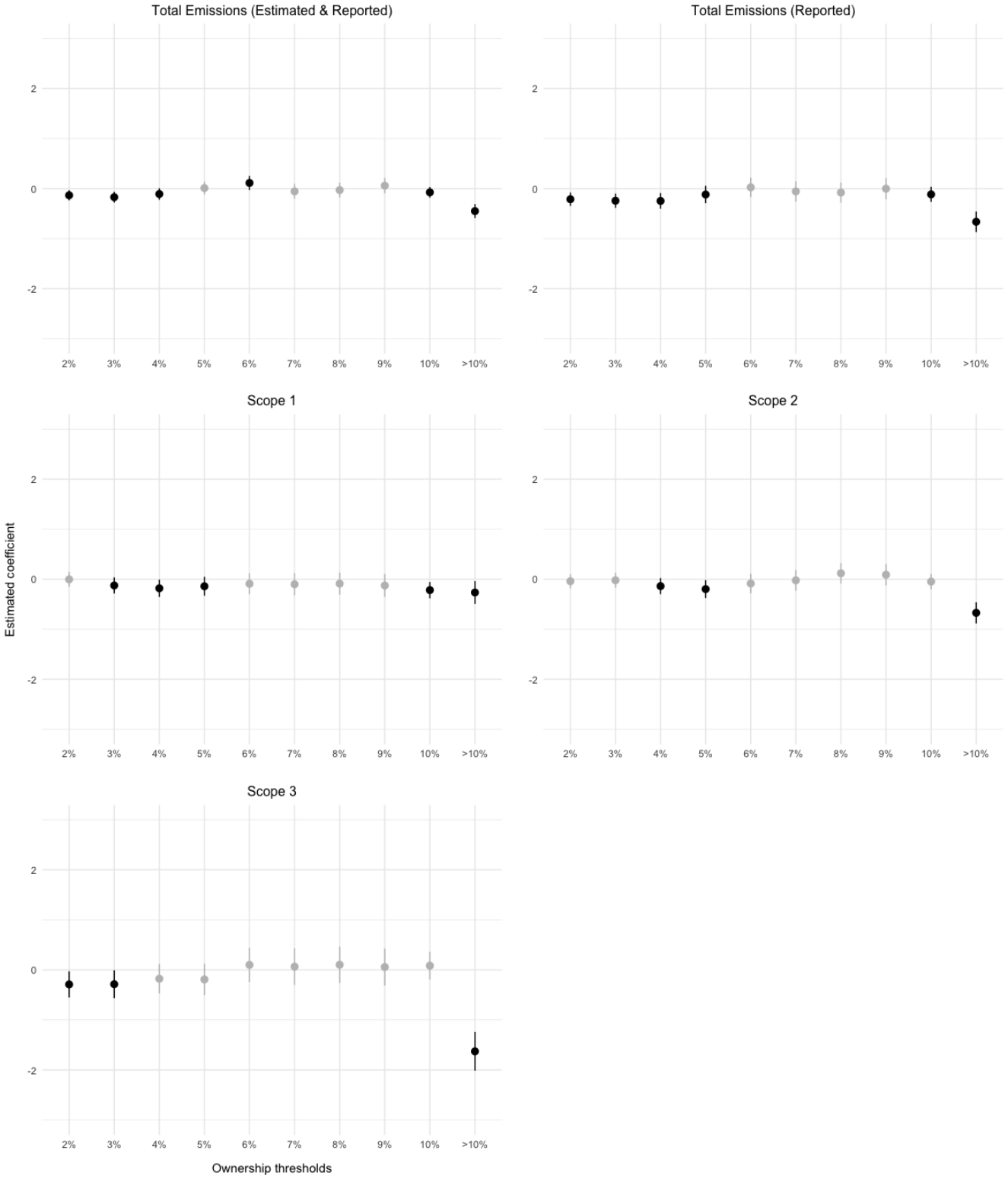
5.7 Effect of Big Three ownership thresholds on firm emissions

We continue the analysis of the effect of holding size on emission reductions. The previous results indicate that meaningful increases in Big Three ownership are not associated with emission reductions. Next, we evaluate whether larger holdings are associated with larger emissions reductions. To test this, we categorize holdings into eleven 1% ownership brackets, [0%, 1%], [1%, 2%], …, [9%, 10%] and > 10%. An indicator variable is set to one if it belongs to an ownership brackets, and zero otherwise. Equation 1 is re-specified by replacing *Big3_hldg* with these separate indicator variables. The results are shown in **Figure 2** Panel A (industry and country fixed effects) and Panel B (firm and year fixed effects).

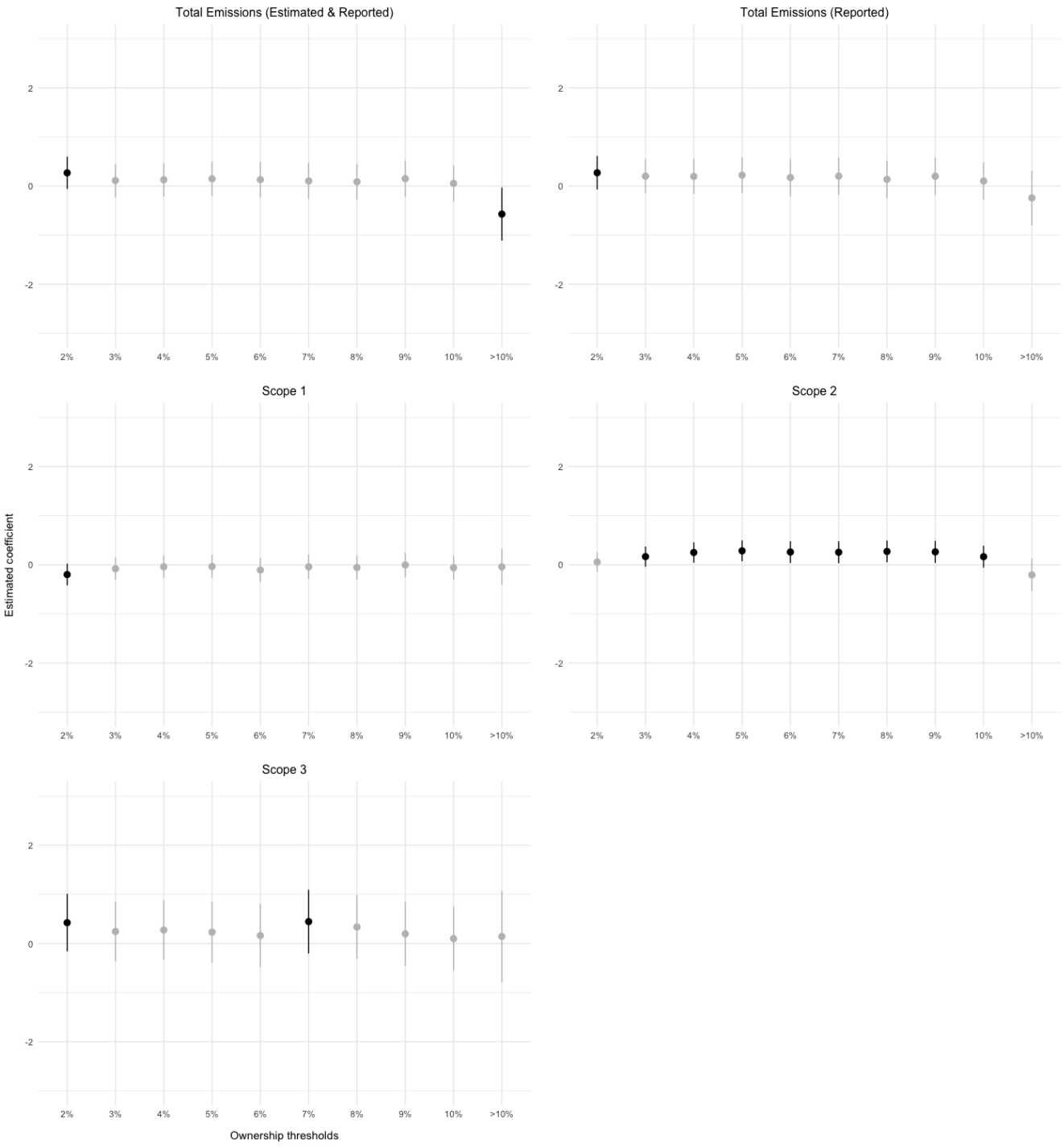
In contrast to Azar et al.'s (2021) findings, our analysis does not reveal a pattern of increasingly negative coefficients with increasing holding size. Instead, the results show a fairly constant, negative coefficient across all ownership thresholds, with the

Figure 4 Big Three ownership thresholds and carbon emissions. The analysis in **Table 4** is repeated with *Big3_hldg* variable replaced by indicator variables marking 1% holding intervals. The first indicator variable equals 1 if *Big3_hldg* is between 0% and 1%, the second indicator is equal to 1 if *Big3_hldg* is between 1% and 2%, and so on up to the last indicator variable equal to 1 if *Big3_hldg* >10%. The first indicator is omitted from the regression and serves as a benchmark. Panel A shows the results from the regressions including country and industry fixed effects, and Panel B reports results from the regressions with firm and year fixed effects. The dependent variable is the logarithm of CO_2 emissions broken down by scope as in the previous regressions. Vertical lines indicate 99% confidence intervals, black dot indicates significance at 10%

Panel A. Model with industry and country fixed effects



Panel B. Model with more stringent firm and year fixed effects



exception of the threshold larger than 10%. Ownership thresholds larger than 10% are associated with coefficients of -0.45*** and -0.66*** for total emissions with and without estimated data respectively, and coefficients of -0.27**, -0.67*** and -1.63*** for Scope 1, 2 and 3 emissions respectively. There are 3 772 firms, or 29.55% of unique firms, in the Big Three's portfolio where combined holdings is greater than 10%. These findings lend weight to Azar et al.'s (2021) conjecture that "firms respond to the Big Three's requests to reduce emissions only when these investors can be pivotal in key voting items."

Figure 4 Panel A replicates Azar et al.'s (2021) analysis and uses the same industry and country fixed effects as the authors. However, this combination of fixed effects attributes the effects of time variant variables such as regulations, mandatory reporting and net zero pledges to the Big Three. To rectify this, we re-run the model using firm and year fixed effects and present the results in Figure 4 Panel B and obtain similar results for total estimated and reported emissions. However, when we remove estimated emissions, this association is no longer significant. Large ownership thresholds are no longer associated with reduced total reported emissions, but positive Scope 2 and 3 emissions under a more appropriate fixed effects model. The implication is that firms are reducing their emissions, but it is not the Big Three that are driving them under a firm and year fixed effects model.

6 Conclusion

We investigate the role of the Big Three in reducing corporate carbon emissions by replicating Azar et al.s' (2021) paper using data in the same time period of 2005 to 2018. We find that contrary to Azar et al. (2021), neither Big Three nor Non-Big Three ownership is associated with reduced firm emissions in 2005-2018, and we hypothesize that fundamentally different data sets are the source of the divergence. Our sample covers all of Big Three's holdings, where Azar et al.s' (2021) covers only their mutual funds. In addition, an early data set that is pre-Paris agreement, is comprised of mostly estimated emissions data. In our sample set, up to 60% of our 2005-2018 dataset is estimated. Given that lack of carbon accounting standardization and low carbon reporting rates is a global problem, it is likely that Azar et al.'s (2021) sample also

suffers from the same high proportion of estimated data. Regressions based on estimated data could pick up patterns associated with the estimation method, not with reported emissions, and provide unreliable results.

When we use a later sample period of 2014 to 2022, we find that both Big Three and Non-Big Three holdings are associated with lower firm emissions. This reflects the increased focus on climate change instigated by the adoption of the Paris Agreement in 2015 that has impacted all investors. The Paris Agreement has put a greater focus on transparency and reporting, which results in higher levels of carbon reporting. The proportion of estimated data drops form 60% 2005-2018 to 40% 2014-2022. We find that Vanguard is the driver behind the negative association between Big Three ownership and emissions, not Blackrock and State Street as in Azar et al.s' (2021) 2005-2018 analysis.

Next, we analyze if larger Big Three holdings are associated with emission reductions. Like Azar et al. (2021), we do observe that larger ownership thresholds are associated with emission reductions when industry and country fixed effects are used, but only when holdings are greater than 10%. However, this combination of fixed effects incorrectly attributes the effects of variations such as regulations and mandatory reporting to the Big Three, and we thus use firm and year fixed effects as an alternative. Under this new, more appropriate, fixed effects model, we no longer observe that larger ownership thresholds are associated with emission reductions. Since larger ownership thresholds are not associated with emission reductions, it follows that meaningful increases in Big Three holdings are not associated with firm emission reductions in our analysis.

Next, we analyze the effect of Big Three holdings on emissions over time. We do not observe a persistence of changes in Big Three ownership on changes in firm emissions over time, nor an increasingly negative pattern when coefficients are plotted by year. Interestingly, Non-Big Three ownership does exhibit a consistent pattern of negative coefficients year-by-year, which again reflects the increased industry focus on carbon risk post-Paris Agreement.

Overall, our findings are consistent with the Azar et al. (2021) and the literature that institutional owners, represented by the Big Three and Non-Big Three, are associated

with reduced emissions. However, contrary to Azar et al. (2021), we do not find that this association strengthens throughout time or as holding size increases.

Given the importance of correctly specifying fixed effects models in attributing effects correctly to the Big Three, we would be interested in applying firm-year and industry-year firm fixed effects to further sharpen identification of the effects of Big Three. Other avenues for further work involve replicating Azar et al. (2021)'s dataset to determine if estimated data has caused bias in their results, the establishment of a more robust carbon intensity specification that considers the relationship between sales and emissions and a more ambitious exploration of the size of beta required for the Big Three to affect net zero by 2050.

Appendix 1 Overview of Results

Table 8 Summary of models and results. (+E) Total emissions with estimated data, (-E) Total reported emissions without estimated data, (S1) Scope 1 emissions, (S3) Scope 2 emissions, (S3) Scope 3 emissions.

Model	Sample Period	With MSCI split	Summary of Results	Agrees with Azar et al.s' (2021) results?	Explanation
Big3_hldg vs. *log(CO_2)* aggregate coefficient	2005-2018	Y	**Table 3** Big Three: (+E) Positive association (-E) No association	N	Differences in datasets driving the deviation between our and Azar et al.s' (2021) results. Our sample has a more complete, broader coverage of Big Three holdings skewed towards larger firms. Most of our sample data is pre-Paris agreement, when carbon accounting is less reliable.
Big3_hldg vs. *log(CO_2)* aggregate coefficient from	2014-2022	Y	**Table 4**. Big Three: (+E) Negative association MSCI and non-MSCI (-E) Negative association MSCI Non-Big Three: (+E) No association (-E) Negative non-MSCI	Y	Big Three associated with reduced firm emissions for both MSCI and non-MSCI firms. Most of our sample data is post-Paris agreement and our results reflect the increased focus on climate change as a result of the agreement. When estimated data is removed, the coefficient becomes larger and less significant for MSCI firms and Big Three no longer associated with reduced emissions for non-MSCI firms.
Big3_hldg vs. *log(CO_2)* aggregate coefficient	2014-2022	N	**Table 12** Big Three: (+E) Negative association (-E) Negative association (S2) Negative association Non-Big Three: (+E) No association (-E) Negative association (S1) Negative association	Y	Azar et al. (2021) hypothesize that Big Three focus engagement efforts on MSCI firms and split firms into MSCI and non-MSCI. We remove this split and find that Big Three and Non-Big Three are associated with reduced total reported emissions.
Blackrock_hldg, *Statestreet_hldg*, *Vanguard_hldg* vs. *log(CO_2)*	2014-2022	Y	**Table 7** Blackrock: (+E) No association (S2) Negative association MSCI State Street: (+E) Positive association non-MSCI (S1) Positive association MSCI (S2) Positive association MSCI and non-MSCI Vanguard: (+E) Negative association MSCI and non-MSCI (-E) Negative association MSCI and non-MSCI (S1) Negative association MSCI (S2) Negative association MSCI Non-Big Three: (+E) Negative association MSCI (-E) Negative association non-MSCI	N	Azar et al. (2021) find that Blackrock and State Street are associated with reduced firm emissions in 2005-2018, and we find that it is Vanguard from 2014-2022. We also find that Non-Big Three are associated with reduced firm emissions of non-MSCI firms.
Big3_increase larger than 1% vs. *log(CO_2)*	2014-2022	Y	**Table 5** Big Three: (+E) No association (-E) No association Non-Big Three: (+E) Negative association non-MSCI (-E) Negative association non-MSCI	N	We do not find an association between meaningful increases in Big Three holdings and firm emissions reductions. Although the findings are opposite to Azar et al.s' (2021), they concur with our findings that larger ownership thresholds are not associated with larger emission reductions. A non-negligible increase in Non-Big Three holdings is associated with reduced non-MSCI firm emissions.

Model	Sample Period	With MSCI split	Summary of Results	Agrees with Azar et al.s' (2021) results?	Explanation
Big3_increase larger than 1% vs. *log(CO_2)*	2014-2022	N	**Table 13** Big Three: (+E) Negative association MSCI (-E) No association Non-Big Three: (+E) No association (-E) No association	Y	Similar findings to when we split between MSCI and non-MSCI, a non-negligible increase in Big Three holdings is associated with reduced MSCI firm emissions, but not when estimated data is removed. When firms not split by MSCI membership, it appears as if Non-Big Three do not have an effect on emissions.
Big3_hldg split into 1% intervals of ownership thresholds vs. *log(CO_2)*	2014-2022	Y	**Figure 2** (+E) Association between ownership threshold >10% and reduced firm emissions (-E) Association between ownership threshold >10% and reduced firm emissions	Y but not when estimate data removed	We do not observe a downward pattern like Azar et al. (2021), but we do observe a negative association between ownership thresholds larger than 10% and emissions under an industry and country fixed effects model. This association becomes insignificant under a firm and year fixed effects model when estimated data is removed.
Δ_Big3_hldg vs. *Δ_CO_2* over time	2014-2022	Y	**Table 6** Big Three: (+E) No association (-E) No association Non-Big Three: (+E) No association (-E) No association	N	We do not find persistence of effects of ownership on changes in emissions.
Big3_hldg vs. *log(CO_2)* coefficients by year	2014-2022	Y	**Figure 1** No downward trend in coefficients over time	N	We do not observe a similar pattern as Azar et al.s' (2021) when we plot coefficients over time. We cannot draw any meaningful conclusions of the association between Big Three ownership and MSCI or non-MSCI firm emissions over time. However, Non-Big Three ownership is associated with negative MSCI firm emissions over time. This finding confirms the findings from *Big3_hldg* vs. *log(CO_2)* and *Big3_increase* vs. *log(CO_2)* of Non-Big Three holdings and negative emissions for non-MSCI firms.

Appendix 2 Refinitiv CO_2 emission calculation methodology

Refinitiv follows a four step model to provide company CO_2 emissions data:

1. Reported: The reported CO_2 emissions data from the company is provided, if available. If data is not reported by the company the model proceeds to the nexts step(s).
2. CO_2 model: If the company has not (yet) reported CO_2 emissions for the current year the following estimation is performed:
    a. The latest available total CO_2 emissions is divided by the number of employees for the same year as the CO_2 emissions, and then multiplied by the number of employees for the current year.
    b. The same calculation as in the previous point is performed using net sales (in USD) instead of number of employees
    c. CO_2 model returns the average of the numbers in the previous steps, or just one of them if not both are available.
3. Energy model: If CO_2 model is unable to return a figure the estimation in the Energy model is performed:
    a. The latest available total energy consumed (total energy produced for companies in the utilities sector) is divided by the number of employees of the same year as total energy.
    b. The same calculation is performed for all the other companies in the same industry (extended to industry group if available estimates are fewer than 10) and the percentile rank of the target company is computed.
    c. The previous step is repeated using CO_2 instead of energy to obtain a percentile rank on the same industry classification level as used for total energy percentile.The percentile is used to find the ratio for the CO_2 number which is multiplied by number of employees for the target year.
    d. The previous steps are repeated using net sales (in USD) instead of number of employees
    e. Energy model returns the average of the numbers obtained, or just one of them if the other is not available.

4. Median model: If the Energy model is unable to return a value the estimation in the Median model is performed:

    a. The ratio of CO_2 /number of employees is calculated for all companies in the same industry, using a classification level that provides at least 10 available ratios, in the year for which an estimate is computed.

    b. The median of the numbers in the previous step is computed and multiplied by the number of employees of the target company.

    c. The previous steps are repeated using net sales (in USD) instead of number of employees.

    d. The Median model returns the average of the two numbers, or just one if the other is not available.

Appendix 3 Statistics on data for sample period 2005-2018

Table 9 Descriptive statistics of sample data 2005-2018.

Panel A. Descriptive statistics of key variables

	MSCI					Non-MSCI				
	Std dev	P25	Median	Mean	P75	Std dev	P25	Median	Mean	P75
Log(CO2)	2.54	11.00	12.52	12.77	14.31	2.76	9.20	11.02	11.10	12.74
Big3_hldg	0.069	0.015	0.035	0.067	0.106	0.085	0.009	0.038	0.078	0.134
BlackRock_hldg	0.032	0.007	0.019	0.033	0.056	0.045	0.003	0.022	0.041	0.068
StateStreet_hldg	0.018	0.001	0.002	0.012	0.014	0.015	0.001	0.003	0.011	0.020
Vanguard_hldg	0.029	0.004	0.011	0.024	0.029	0.034	0.004	0.018	0.033	0.057
NonBig3_hldg	0.233	0.200	0.343	0.392	0.590	0.275	0.192	0.439	0.437	0.688
Controls:	1.52	22.08	22.94	23.15	24.07	2.04	20.52	21.49	21.82	22.75
Size	1.60	-1.89	-0.99	-1.38	-0.34	0.98	-1.33	-0.75	-0.85	-0.27
Log(BM)	0.07	0.01	0.04	0.04	0.07	0.12	0.01	0.03	0.02	0.07
ROA	0.17	0.12	0.23	0.25	0.36	0.17	0.09	0.21	0.23	0.34
Leverage	0.25	0.06	0.20	0.27	0.41	0.27	0.02	0.15	0.25	0.40
PPE	2.54	11.00	12.52	12.77	14.31	2.76	9.20	11.02	11.10	12.74

Panel B. Descriptive statistics of sample distribution by country

	MSCI					Non-MSCI				
	# obs.	% obs.	# firms	Mean CO2 (millions tons)	Mean Big3_hldg	# obs.	% obs.	# firms	Mean CO2 (millions tons)	Mean Big3_hldg
Australia	825	4.63	87	17.74	0.05	1144	8.84	260	5.78	0.02
Austria	151	0.85	13	10.27	0.02	36	0.28	17	1.01	0.03
Belgium	215	1.21	21	2.14	0.03	97	0.75	31	1.53	0.03
Canada	1156	6.48	121	3.57	0.03	1488	11.5	292	0.97	0.03
Denmark	268	1.5	25	3.93	0.02	94	0.73	24	0.67	0.02
Finland	229	1.28	20	5.04	0.04	129	1	24	3.13	0.01
France	933	5.23	90	13.53	0.03	286	2.21	102	32.79	0.02
Germany	743	4.17	87	22.01	0.05	395	3.05	110	11.71	0.03
Hong Kong	881	4.94	119	4.02	0.02	114	0.88	30	2.73	0.01
Ireland	168	0.94	31	8.71	0.12	82	0.63	25	3.41	0.05
Israel	119	0.67	15	0.83	0.02	27	0.21	8	0.52	0.01
Italy	327	1.83	38	18.85	0.03	299	2.31	81	15.73	0.02
Japan	4440	24.9	421	5.66	0.03	409	3.16	58	9.76	0.01
Netherlands	275	1.54	37	2.02	0.05	221	1.71	51	4.63	0.02
New Zealand	108	0.61	13	0.42	0.04	108	0.83	30	0.72	0.01
Norway	128	0.72	13	19.87	0.02	121	0.93	37	15.41	0.01
Portugal	71	0.4	8	6.35	0.03	58	0.45	13	1.07	0.01
Singapore	322	1.81	34	1.47	0.03	78	0.6	15	8.25	0.01
Spain	324	1.82	37	17.79	0.03	230	1.78	50	4.21	0.01
Sweden	365	2.05	38	1.59	0.03	352	2.72	102	1.87	0.02
Switzerland	586	3.29	58	11.25	0.05	304	2.35	83	4.01	0.02
UK	1358	7.61	142	23.91	0.08	1992	15.39	319	25.56	0.05
USA	3842	21.54	671	8.13	0.17	4880	37.7	1716	0.94	0.16

Panel C. Descriptive statistics of sample distribution by industry

	MSCI					Non-MSCI				
	# obs.	% obs.	# firms	Mean CO2 (millions tons)	Mean Big3_hldg	# obs.	% obs.	# firms	Mean CO2 (millions tons)	Mean Big3_hldg
Utilities	1053	5.9	119	36.41	0.07	422	3.26	115	22.78	0.08
Real Estate	861	4.83	108	0.54	0.07	642	4.96	157	0.34	0.09
Financials	2440	13.68	280	0.27	0.07	2466	19.05	683	0.21	0.08
Consumer Staples	3663	20.54	410	4.64	0.06	2345	18.12	617	1.14	0.09
Consumer Discretionary	3070	17.21	356	7.58	0.06	2015	15.57	534	2.47	0.08
Energy	1523	8.54	158	24.39	0.05	1302	10.06	274	14.47	0.06
Industrials	1210	6.78	142	3.61	0.06	657	5.08	163	3.66	0.05
Telecommunications	1207	6.77	164	0.69	0.09	982	7.59	357	0.58	0.09
Basic Materials	1145	6.42	159	1.65	0.08	694	5.36	223	0.56	0.1
Health Care	1018	5.71	125	43.18	0.07	972	7.51	217	54.44	0.06
Technology	644	3.61	84	1.77	0.06	447	3.45	113	2.05	0.05

Appendix 4 Regression results for sample period 2005-2018

Table 10 Big Three ownership and different specifications of firm carbon emissions from 2005 to 2018. The sample covering total estimated and reported CO_2 emissions includes 8,906 firm-year observations in the MSCI subsample and 26,143 firm-year observations in the non-MSCI subsample. We use total estimated and reported emissions as a direct replication of Azar et al.'s (2021) paper. *Big3_hldg*, the independent variable, is the percentage of the firm's equity owned by Blackrock, Vanguard or State Street. The regression includes *NonBig3_hldg* as an independent variable, defined as the percentage of the firms' equity owned by funds managed by institutions other than the Big Three. The control variables are as defined in Section 2. Columns (1)-(3) report results corresponding to the subsample of firms that are members of the MSCI World Index. Columns (4)-(6) report results corresponding to the subsample of firms that are not members of this index. Intercepts are omitted. ***, **, *, and . denote significance at 0.1%, 1%, 5% and 10% respectively.

Panel A. Our results based on total estimated and reported emissions

	Dependent variable: Log(Total estimated and reported CO_2)					
	MSCI			Non-MSCI		
	(1)	(2)	(3)	(4)	(5)	(6)
Big3_hldg	1.53***	1.35***	1.14***	-0.14	-0.04	-0.24
	(4.67)	(3.78)	(3.65)	(-0.53)	(-0.14)	(-0.83)
NonBig3_hldg	-0.22**	-0.2**	0.28**	-0.18**	-0.18**	-0.13
	(-2.92)	(-2.69)	(3.09)	(-2.84)	(-2.82)	(-1.55)
Size	1.08***	1.08***	0.29***	1.04***	1.04***	0.4***
	(116.73)	(116.54)	(12.13)	(123.86)	(119.51)	(15.38)
Log(BM)	-0.02**	0	0.03***	-0.18***	-0.17***	-0.09***
	(-2.64)	(-0.38)	(5.18)	(-13.01)	(-12.05)	(-7.32)
ROA	1.09***	1.13***	0.3*	0.34***	0.33***	0.02
	(7.07)	(7.24)	(2.57)	(6.28)	(6.17)	(0.69)
Leverage	0.02	0.03	0.27**	-0.09	-0.09	-0.08
	(0.33)	(0.43)	(2.87)	(-1.16)	(-1.11)	(-0.83)
PPE	2.1***	2.09***	0.2*	1.89***	1.86***	0.18*
	(35.23)	(35.05)	(2.47)	(29.87)	(29.33)	(2.18)
Country FE	Y	Y	N	Y	Y	N
Industry FE	Y	Y	N	Y	Y	N
Year FE	N	Y	Y	N	Y	Y
Firm FE	N	N	Y	N	N	Y
R2	0.67	0.67	0.91	0.74	0.74	0.96
# obs.	17834	17834	17834	12932	12932	12932

Panel A. Azar's results based on total estimated and reported emissions

	Dependent variable: Log(Total estimated and reported CO_2)					
	MSCI			Non-MSCI		
	(1)	(2)	(3)	(4)	(5)	(6)
Big3_hldg	-3.44***	-1.69**	-1***	-0.76	0.66	0.46
	(-5.76)	(-2.27)	(-2.83)	(-1.09)	(-1.41)	(-1.6)
NonBig3_hldg	-0.04	-0.12	-0.07	0.36***	0.26**	0.18**
	(-0.25)	(-0.74)	(-0.75)	(-3.43)	(-2.5)	(-2.47)
Size	0.79***	0.8***	0.55***	0.81***	0.79***	0.56***
	(-42.88)	(-42.21)	(-13.77)	(-50.85)	(-54.5)	(-14.96)
Log(BM)	0.01	0.01	-0.02	-0.06***	-0.06***	-0.05***
	(-0.55)	(-0.3)	(-2.29)	(-3.25)	(-3.16)	(-4.36)
ROA	1.52***	1.53***	0.89***	2.95***	2.83***	0.57***
	(-4.55)	(-4.65)	(-5.39)	(-14.26)	(-12.89)	(-6.3)
Leverage	0.03	0.02	0.05	0.38***	0.41***	0.17**
	(-0.23)	(-0.15)	(-0.69)	(-3.03)	(-3.29)	(-2.22)
PPE	1.27***	1.27***	-0.01	1.19***	1.15***	0.51***
	(-8.32)	(-8.24)	(-0.08)	(-12.01)	(-11.54)	(-4.38)
Country FE	Y	Y	N	Y	Y	N
Industry FE	Y	Y	N	Y	Y	N
Year FE	N	Y	Y	N	Y	Y
Firm FE	N	N	Y	N	N	Y
R2	0.75	0.75	0.98	0.73	0.74	0.98
# obs.	19224	19224	19134	22969	22969	22468

Appendix 5 Regression results for sample period 2014-2022

Table 11 Big Three ownership and different specifications of firm carbon emissions from 2014 to 2022. The sample covering total estimated and reported CO_2 emissions includes 8,906 firm-year observations in the MSCI subsample and 26,143 firm-year observations in the non-MSCI subsample. We use different specifications for the dependent variable representing CO_2 emissions, beginning with total estimated and reported emissions as a direct replication of Azar et al.'s (2021) paper. We then test the robustness of this result by removing estimated emissions. Following this, we break down total reported emissions into Scope 1, 2 and 3 emissions. *Big3_hldg*, the independent variable, is the percentage of the firm's equity owned by Blackrock, Vanguard or State Street. The regression includes *NonBig3_hldg* as an independent variable, defined as the percentage of the firms' equity owned by funds managed by institutions other than the Big Three. The control variables are as defined in Section 2. Columns (1)-(3) report results corresponding to the subsample of firms that are members of the MSCI World Index. Columns (4)-(6) report results corresponding to the subsample of firms that are not members of this index. Intercepts are omitted. ***, **, *, and . denote significance at 0.1%, 1%, 5% and 10% respectively.

Panel A. CO_2 specified as total estimated and reported emissions

	Dependent variable: Log(Total estimated and reported CO_2)					
	MSCI			Non-MSCI		
	(1)	(2)	(3)	(4)	(5)	(6)
Big3_hldg	3.2***	3.03***	-1.47**	-1.09***	-0.76***	-0.49*
	(6.45)	(5.59)	(-2.72)	(-5.39)	(-3.72)	(-2.28)
NonBig3_hldg	-0.9***	-0.89***	-0.63**	-0.4***	-0.51***	0.11
	(-6.08)	(-5.92)	(-3.03)	(-7.04)	(-8.97)	(1.46)
Size	1.31***	1.34***	0.23***	1.14***	1.14***	0.22***
	(60.69)	(60.76)	(6.86)	(139.86)	(137.44)	(13.21)
Log(BM)	0.05.	0.03	-0.15***	-0.14***	-0.15***	-0.05***
	(1.91)	(0.93)	(-5.05)	(-10.48)	(-11.18)	(-4.07)
ROA	2.88***	2.55***	0.37	2.02***	1.73***	0.44***
	(7.58)	(6.57)	(1.16)	(17.81)	(15.18)	(4.5)
Leverage	-0.25.	-0.36*	0.01	0.3***	0.28***	0.33***
	(-1.80)	(-2.57)	(0.06)	(4.54)	(4.28)	(4.36)
PPE	2.47***	2.42***	0.61**	2.52***	2.51***	0.14
	(21.06)	(20.64)	(2.92)	(42.25)	(42.34)	(1.4)
Country FE	Y	Y	N	Y	Y	N
Industry FE	Y	Y	N	Y	Y	N
Year FE	N	Y	Y	N	Y	Y
Firm FE	N	N	Y	N	N	Y
R2	0.62	0.62	0.93	0.70	0.71	0.95
# obs.	8 906	8 906	8 906	26 143	26 143	26 143

Panel B. CO_2 specified as total reported emissions

	Dependent variable: Log(Total reported CO_2)					
	MSCI			Non-MSCI		
	(1)	(2)	(3)	(4)	(5)	(6)
Big3_hldg	3***	2.59***	-1.37*	-2.54***	-2.49***	-0.51
	(5.55)	(4.41)	(-2.43)	(-6.83)	(-6.62)	(-1.33)
NonBig3_hldg	-1.11***	-1.07***	-0.27	-0.53***	-0.56***	0.25*
	(-6.88)	(-6.57)	(-1.26)	(-5.75)	(-6.16)	(2.12)
Size	1.24***	1.26***	0.3***	1.22***	1.23***	0.28***
	(51.23)	(51.36)	(7.89)	(90.32)	(88.65)	(11.03)
Log(BM)	0.1***	0.08**	-0.18***	-0.08***	-0.11***	-0.04*
	(3.39)	(2.63)	(-5.84)	(-3.71)	(-4.67)	(-2.18)
ROA	2.79***	2.49***	0.29	1.74***	1.29***	0.51**
	(6.28)	(5.45)	(0.86)	(7.09)	(5.18)	(3.22)
Leverage	-0.27.	-0.38*	-0.08	0.2.	0.15	0.38**
	(-1.8)	(-2.48)	(-0.46)	(1.81)	(1.35)	(3.18)
PPE	2.06***	2.02***	0.77***	2.83***	2.8***	0.48**
	(16.41)	(16.1)	(3.57)	(30.58)	(30.29)	(3.25)
Country FE	Y	Y	N	Y	Y	N
Industry FE	Y	Y	N	Y	Y	N
Year FE	N	Y	Y	N	Y	Y
Firm FE	N	N	Y	N	N	Y
R2	0.61	0.61	0.93	0.6	0.61	0.94
# obs.	7691	7691	7691	13227	13227	13227

Panel C. CO_2 specified as Scope 1 emissions

	Dependent variable: Log(Scope 1 emissions)					
	MSCI			Non-MSCI		
	(1)	(2)	(3)	(4)	(5)	(6)
Big3_hldg	0.69	2.44***	-0.25	-2.58***	-1.69***	-0.09
	(1.29)	(4.26)	(-0.7)	(-5.97)	(-3.91)	(-0.33)
NonBig3_hldg	-0.38*	-0.62***	0	-0.28**	-0.44***	-0.13
	(-2.39)	(-3.86)	(0.01)	(-2.59)	(-4.19)	(-1.61)
Size	1.12***	1.12***	0.25***	1.17***	1.13***	0.2***
	(46.16)	(45.58)	(9.65)	(74.04)	(70.32)	(10.47)
Log(BM)	0.46***	0.41***	0.01	0.1***	0.11***	-0.04**
	(15.11)	(13.01)	(0.33)	(3.96)	(4.07)	(-2.88)
ROA	2.4***	1.59***	0.15	1.87***	1.16***	0.34**
	(5.37)	(3.49)	(0.71)	(6.44)	(3.97)	(2.91)
Leverage	0.02	-0.06	-0.13	0.01	0.09	0.13
	(0.12)	(-0.36)	(-1.16)	(0.11)	(0.72)	(1.57)
PPE	3.93***	3.89***	0.8***	3.96***	3.91***	0.47***
	(31.44)	(31.27)	(5.66)	(36.43)	(36.37)	(4.38)
Country FE	Y	Y	N	Y	Y	N
Industry FE	Y	Y	N	Y	Y	N
Year FE	N	Y	Y	N	Y	Y
Firm FE	N	N	Y	N	N	Y
R2	0.73	0.73	0.98	0.65	0.66	0.98
# obs.	6894	6894	6894	10826	10826	10826

Panel D. CO_2 specified as Scope 2 emissions

	Dependent variable: Log(Scope 2 emissions)					
	MSCI			Non-MSCI		
	(1)	(2)	(3)	(4)	(5)	(6)
Big3_hldg	-0.03	2.83***	-0.37	-2.32***	-1.15**	-0.26
	(-0.06)	(5.43)	(-1.13)	(-5.68)	(-2.83)	(-0.92)
NonBig3_hldg	-0.31*	-0.68***	-0.11	-0.73***	-0.94***	-0.02
	(-2.13)	(-4.69)	(-0.86)	(-7.35)	(-9.57)	(-0.27)
Size	0.98***	0.98***	0.18***	1.03***	0.98***	0.2***
	(44.01)	(44.1)	(7.64)	(69.9)	(65.99)	(10.65)
Log(BM)	0.22***	0.14***	-0.04*	-0.04.	-0.05*	-0.07***
	(8.13)	(4.84)	(-2.17)	(-1.83)	(-2.04)	(-4.57)
ROA	3.16***	1.82***	0.15	2.47***	1.58***	0.17
	(7.83)	(4.48)	(0.76)	(9.13)	(5.86)	(1.43)
Leverage	0.18	0.05	-0.47***	0.22.	0.29*	-0.18*
	(1.26)	(0.37)	(-4.47)	(1.84)	(2.44)	(-2.02)
PPE	1.54***	1.46***	0.37**	1.39***	1.32***	0.5***
	(13.41)	(13.02)	(2.92)	(13.6)	(13.19)	(4.45)
Country FE	Y	Y	N	Y	Y	N
Industry FE	Y	Y	N	Y	Y	N
Year FE	N	Y	Y	N	Y	Y
Firm FE	N	N	Y	N	N	Y
R2	0.51	0.53	0.97	0.5	0.52	0.97
# obs.	7005	7005	7005	11157	11157	11157

Panel E. CO_2 specified as Scope 3 emissions

	Dependent variable: Log(Scope 3 emissions)					
	MSCI			Non-MSCI		
	(1)	(2)	(3)	(4)	(5)	(6)
Big3_hldg	6.82***	5.43***	0.64	-2.4**	-3.32***	1.06
	(7.43)	(5.4)	(0.66)	(-2.94)	(-4.03)	(1.3)
NonBig3_hldg	-2.54***	-2.4***	0.1	-1.1***	-1.01***	0.17
	(-9.56)	(-8.92)	(0.28)	(-5.83)	(-5.4)	(0.67)
Size	1.27***	1.32***	0.35***	1.26***	1.31***	0.27***
	(30.75)	(31.35)	(5.35)	(46.07)	(47.09)	(4.89)
Log(BM)	-0.12*	-0.14**	-0.24***	-0.22***	-0.27***	-0.05
	(-2.33)	(-2.76)	(-4.62)	(-4.82)	(-5.67)	(-1.13)
ROA	1.81*	1.56*	0.08	3.05***	2.97***	0.32
	(2.4)	(2)	(0.15)	(5.46)	(5.23)	(0.79)
Leverage	-1.14***	-1.29***	-0.34	-0.45*	-0.53*	0.26
	(-4.55)	(-5.11)	(-1.13)	(-1.99)	(-2.36)	(1)
PPE	1.06***	1.01***	1**	2.55***	2.54***	-0.4
	(4.81)	(4.59)	(2.6)	(12.26)	(12.31)	(-1.17)
Country FE	Y	Y	N	Y	Y	N
Industry FE	Y	Y	N	Y	Y	N
Year FE	N	Y	Y	N	Y	Y
Firm FE	N	N	Y	N	N	Y
R2	0.53	0.53	0.92	0.49	0.5	0.93
# obs.	5490	5490	5490	6758	6758	6758

Table 12 Non-negligible changes in Big Three ownership full regression results. We repeat **Error! Reference source not found.** using changes in ownership instead of levels. *Big3_hldg* is replaced with *Big3_incr*, an indicator variable that equals one if *Δ_Big3_hldg* > 1% and zero otherwise. *NonBig3_incr* is defined as one if *Δ_NonBig3_hldg* > 1% and zero otherwise. Panel A presents the results for *Big3_incr*, and the results for *NonBig3_incr* are shown in Panel B. The sample spans from 2014 to 2022 and includes 8,827 firm-year observations in the MSCI subsample and 24,930 firm-year observations in the non-MSCI subsample. Intercepts are omitted. ***, **, * and . denote significance at 0.1%, 1%, 5% and 10% respectively.

	Dependent variable: Log(Total estimated and reported CO_2)					
	MSCI			Non-MSCI		
	(1)	(2)	(3)	(4)	(5)	(6)
Big3_increase	-0.06	-0.05	-0.03	-0.01	-0.07**	-0.01
	(-1.48)	(-1.06)	(-1.19)	(-0.29)	(-2.93)	(-0.37)
NonBig3_increase	-0.04	-0.01	-0.01	0	-0.02	-0.02.
	(-0.91)	(-0.28)	(-0.5)	(0)	(-0.71)	(-1.8)
Size	1.32***	1.35***	0.23***	1.14***	1.14***	0.21***
	(60.33)	(60.4)	(6.58)	(138.96)	(137.86)	(12.41)
Log(BM)	0.06*	0.05	-0.15***	-0.13***	-0.14***	-0.06***
	(2.19)	(1.6)	(-4.98)	(-9.27)	(-10.22)	(-4.73)
ROA	3.14***	2.94***	0.24	1.83***	1.54***	0.47***
	(8.15)	(7.51)	(0.75)	(15.57)	(13.06)	(4.66)
Leverage	-0.26.	-0.36*	0.01	0.32***	0.27***	0.38***
	(-1.85)	(-2.54)	(0.08)	(4.6)	(3.98)	(4.74)
PPE	2.47***	2.44***	0.6**	2.51***	2.5***	0.07
	(21.06)	(20.74)	(2.89)	(41.13)	(41.24)	(0.68)
Country FE	Y	Y	N	Y	Y	N
Industry FE	Y	Y	N	Y	Y	N
Year FE	N	Y	Y	N	Y	Y
Firm FE	N	N	Y	N	N	Y
R2	0.62	0.62	0.93	0.7	0.71	0.95
# obs.	8827	8827	8827	24930	24930	24930

Table 13 Breakdown of ownership full regression results for total estimated and reported emissions. This table repeats the analysis in **Error! Reference source not found.**, breaking down the variable *Big3_hldg* into individual investor holdings. The sample spans from 2014 to 2022 and the sample covering total estimated and reported CO_2 emissions includes 8,965 firm-year observations in the MSCI subsample and 26,430 firm-year observations in the non-MSCI subsample. We use different specifications for the dependent variable representing CO_2 emissions, beginning with total estimated and reported emissions as a direct replication of Azar et al.'s (2021) paper. We then test the robustness of this result by removing estimated emissions. Following this, we break down total reported emissions into Scope 1, 2 and 3 emissions. *Blackrock_hldg*, *Vanguard_hldg* and *Statestreet_hldg* are the fraction of the firm's equity owned by Blackrock, Vanguard or State Street respectively. Intercepts are omitted. ***, **, *, and . denote significance at 0.1%, 1%, 5% and 10% respectively.

Dependent variable: Log(Total estimated and reported CO_2)		
	MSCI	Non-MSCI
	(1)	(2)
BlackRock	-1.1	-0.23
	(-1.48)	(-0.68)
State Street	-2.5	0.93
	(-1.26)	(0.9)
Vanguard	-1.45	-1.75**
	(-1.06)	(-2.71)
NonBig3	-0.62**	0.11
	(-2.98)	(1.45)
Size	0.23***	0.23***
	(6.85)	(13.55)
Log(BM)	-0.15***	-0.05***
	(-5.12)	(-4.31)
ROA	0.32	0.47***
	(1.01)	(4.86)
Leverage	-0.01	0.35***
	(-0.06)	(4.72)
PPE	0.60**	0.09
	(2.89)	(0.90)
Year FE	Y	Y
Firm FE	Y	Y
R2	0.93	0.95
# obs.	8965	26430

Appendix 6 Summary of results 2014 to 2018 (no MSCI split)

6.1 Aggregate effect of Big Three ownership

Table 14 Breakdown of ownership without separation between MSCI and non-MSCI WI firms. This table repeats the analysis in **Error! Reference source not found.**, breaking down the variable *Big3_hldg* into individual investor holdings. The sample spans from 2014 to 2022. We use different specifications for the dependent variable representing CO_2 emissions, beginning with total estimated and reported emissions as a direct replication of Azar et al.'s (2021) paper. We then test the robustness of this result by removing estimated emissions. Following this, we break down total reported emissions into Scope 1, 2 and 3 emissions. *Blackrock_hldg*, *Vanguard_hldg* and *Statestreet_hldg* are the fraction of the firm's equity owned by Blackrock, Vanguard or State Street respectively. Intercepts are omitted. ***, **, *, and . denote significance at 0.1%, 1%, 5% and 10% respectively.

Panel A. Big Three ownership and all firm emissions (no split between MSCI and non-MSCI firms) from 2014 to 2022

Dependent Variable: log(CO_2) with differing specifications as below			
Big3_hldg	**(1)**	**(2)**	**(3)**
Total Emissions (Est. & Rep.)	-3.44**	-1.69*	-1.00***
	(-5.76)	(-2.27)	(-2.83)
Total Emissions (Est. & Rep.)	-0.08	0.13	-0.64**
	(-0.41)	(0.70)	(-3.14)
Total Emissions (Rep.)	-0.06	-0.20	-0.61*
	(-0.02)	(-0.68)	(-1.97)
Scope 1	-1.44	-0.28	-0.30
	(-4.49)	(-0.87)	(-1.42)
Scope 2	-0.43	1.17***	-0.43*
	(-1.44)	(3.84)	(-2.07)
Scope 3	2.09***	0.73	0.58
	(3.66)	(1.24)	(0.96)
Total Emissions (Est. & Rep.)	-0.11	-0.42.	-0.40
	(-0.45)	(-1.66)	(-0.97)
Total Emissions (Rep.)	0.25.	0.03	-0.13
	(1.75)	(0.23)	(-0.48)
Scope 1	-0.09	-0.03	-0.70*
	(-0.59)	(-0.22)	(-2.11)
Scope 2	0.01	0.02	-0.05*
	(0.28)	(0.67)	(-2.29)
Scope 3	-0.91	-1.79*	0.77
	(-1.24)	(-2.37)	(1.58)
Controls	Y	Y	Y
Country FE	Y	Y	N
Industry FE	Y	Y	N
Year FE	N	Y	Y
Firm FE	N	N	Y

Panel B. Non-Big Three ownership and all firm emissions (no split between MSCI and non-MSCI firms) from 2014 to 2022

Dependent Variable: log(CO_2) with differing specifications as below			
NonBig3_hldg	**(1)**	**(2)**	**(3)**
Total Emissions (Est. & Rep.)	-0.04	-0.12	-0.07
	(-0.25)	(-0.74)	(-0.75)
Total Emissions (Est. & Rep.)	-0.46***	-0.54***	0.08
	(-8.56)	(-10.05)	(1.15)
Total Emissions (Rep.)	-0.69***	-0.70**	-0.61*
	(-8.82)	(-9.00)	(-1.97)
Scope 1	-0.28**	-0.46***	-0.15*
	(-3.25)	(-5.41)	(-2.08)
Scope 2	-0.67***	-0.91***	-0.02
	(-8.32)	(-11.56)	(-0.34)
Scope 3	-1.69***	-1.56***	0.31
	(-11.44)	(-10.51)	(1.54)
Total Emissions (Est. & Rep.)	-0.47***	-0.43***	-0.26.
	(-6.80)	(-6.04)	(-1.83)
Total Emissions (Rep.)	-0.31***	-0.29***	-0.26**
	(-8.31)	(-7.75)	(-3.04)
Scope 1	-0.04	-0.05	-0.07
	(-1.08)	(-1.3)	(-0.62)
Scope 2	-0.02**	-0.02**	0.00
	(-2.85)	(-3.08)	(-0.35)
Scope 3	-0.73***	-0.63***	0.31.
	(-3.88)	(-3.31)	(1.9)
Controls	Y	Y	Y
Country FE	Y	Y	N
Industry FE	Y	Y	N
Year FE	N	Y	Y
Firm FE	N	N	Y

6.2 Effect of non-negligible changes in Big Three ownership on firm emissions

Table 15 Non-negligible changes in Big Three ownership without division between MSCI and non-MSCI firms. We repeat **Error! Reference source not found.** using changes in ownership instead of levels. *Big3_hldg* is replaced with *Big3_incr*, an indicator variable that equals one if *Δ_Big3_hldg* > 1% and zero otherwise. *NonBig3_incr* is defined as one if *Δ_NonBig3_hldg* > 1% and zero otherwise. Panel A presents the results for *Big3_incr*, and the results for *NonBig3_incr* are shown in Panel B. The sample spans from 2014 to 2022. We use different specifications for the dependent variable representing CO_2 emissions, beginning with total estimated and reported emissions as a direct replication of Azar et al.'s (2021) paper. We then test the robustness of this result by removing estimated emissions. Following this, we break down total reported emissions into Scope 1, 2 and 3 emissions. Intercepts are omitted. ***, **, * and . denote significance at 0.1%, 1%, 5% and 10% respectively.

Panel A. Effect of non-negligible changes in Big Three ownership on all firm emissions (no split between MSCI and non-MSCI firms)

Dependent Variable: log(CO_2) with differing specifications as below			
Big3_increase	**(1)**	**(2)**	**(3)**
Total Emissions (Est. & Rep.)	-0.10**	-0.04*	-0.02**
	(-4.49)	(-2.52)	(-3.97)
Total Emissions (Est. & Rep.)	-0.01	-0.06**	-0.02.
	(-0.64)	(-2.84)	(-1.75)
Total Emissions (Rep.)	-0.05	-0.06.	-0.02
	(-1.54)	(-1.94)	(-1.43)
Scope 1	0.01	-0.07*	0.00
	(0.36)	(-2.23)	(-0.24)
Scope 2	0.05.	-0.05	-0.01
	(1.73)	(-1.46)	(-1.14)
Scope 3	-0.11.	-0.06	0.01
	(-1.94)	(-1.02)	(0.41)
Total Emissions (Est. & Rep.)	-0.06*	-0.05	-0.01
	(-2.04)	(-1.59)	(-0.44)
Total Emissions (Rep.)	-0.03	-0.03	-0.01
	(-1.64)	(-1.46)	(-0.66)
Scope 1	0.03	0.01	0.01
	(1.63)	(0.78)	(0.78)
Scope 2	0.00	0.00	0.00
	(-0.79)	(-1.17)	(-0.2)
Scope 3	-0.12	-0.09	0
	(-1.62)	(-1.21)	(0.15)
Controls	Y	Y	Y
Country FE	Y	Y	N
Industry FE	Y	Y	N
Year FE	N	Y	Y
Firm FE	N	N	Y

Panel B. Effect of non-negligible changes in Non-Big Three ownership on all firm emissions (no split between MSCI and non-MSCI firms)

Dependent Variable: log(CO_2) with differing specifications as below			
NonBig3_increase	**(1)**	**(2)**	**(3)**
Total Emissions (Est. & Rep.)	-0.02	-0.04.	-0.01.
	(-0.65)	(-2.05)	(-1.93)
Total Emissions (Est. & Rep.)	0.00	-0.01	-0.01
	(-0.16)	(-0.26)	(-1.33)
Total Emissions (Rep.)	0.00	0.01	-0.01
	(-0.03)	(0.43)	(-1.05)
Scope 1	0.07*	0.04	-0.02.
	(2.40)	(1.21)	(-1.69)
Scope 2	0.06*	0.01	-0.01
	(2.20)	(0.52)	(-0.6)
Scope 3	-0.09.	-0.04	-0.01
	(-1.90)	(-0.85)	(-0.21)
Total Emissions (Est. & Rep.)	-0.02	0.00	0.01
	(-0.75)	(-0.17)	(0.68)
Total Emissions (Rep.)	-0.01	0.00	0.00
	(-0.92)	(-0.09)	(0.33)
Scope 1	0.03.	0.03.	0.02
	(1.81)	(1.85)	(1.29)
Scope 2	0.00	0.00	0.00
	(1.11)	(1.03)	(1.33)
Scope 3	-0.03	0	0.04.
	(-0.4)	(-0.02)	(1.76)
Controls	Y	Y	Y
Country FE	Y	Y	N
Industry FE	Y	Y	N
Year FE	N	Y	Y
Firm FE	N	N	Y

6.3 Effect of changes in Big Three ownership on changes in firm emissions over time

Table 16 Changes in ownership vs. changes in total estimated and reported firm emissions over time. In this analysis, the dependent variable is *Δ_* CO_2 *(t-s, t)* defined as the fractional change in total estimated and reported CO_2 emissions from year t-s to year t. *Δ_Big3_hldg (t-s-1, t-1*) and *Δ_NonBig3_hldg (t-s-1, t-1)* is the change in *Big3_hldg* and *NonBig3_hldg* from year *t-s-1* to year *t-1* respectively. The sample spans from 2014 to 2022 and includes XXX firm-year observations in the entire sample. The dependent variable is the logarithm of CO_2 (i.e. the firm's total GHG emissions measured in equivalents of tonnes of CO_2e). We use different specifications for CO_2, beginning with total estimated and reported emissions as a direct replication of Azar et al.'s (2021) paper. We then test the robustness of this result by removing estimated emissions. Following this, we break down total reported emissions into Scope 1, 2 and 3 emissions. Regressions on different specifications of emissions yield similar, non-significant results, and are not included here. Intercepts are omitted and standard errors are not clustered. ***, **, * and . denote significance at 0.1%, 1%, 5% and 10% respectively.

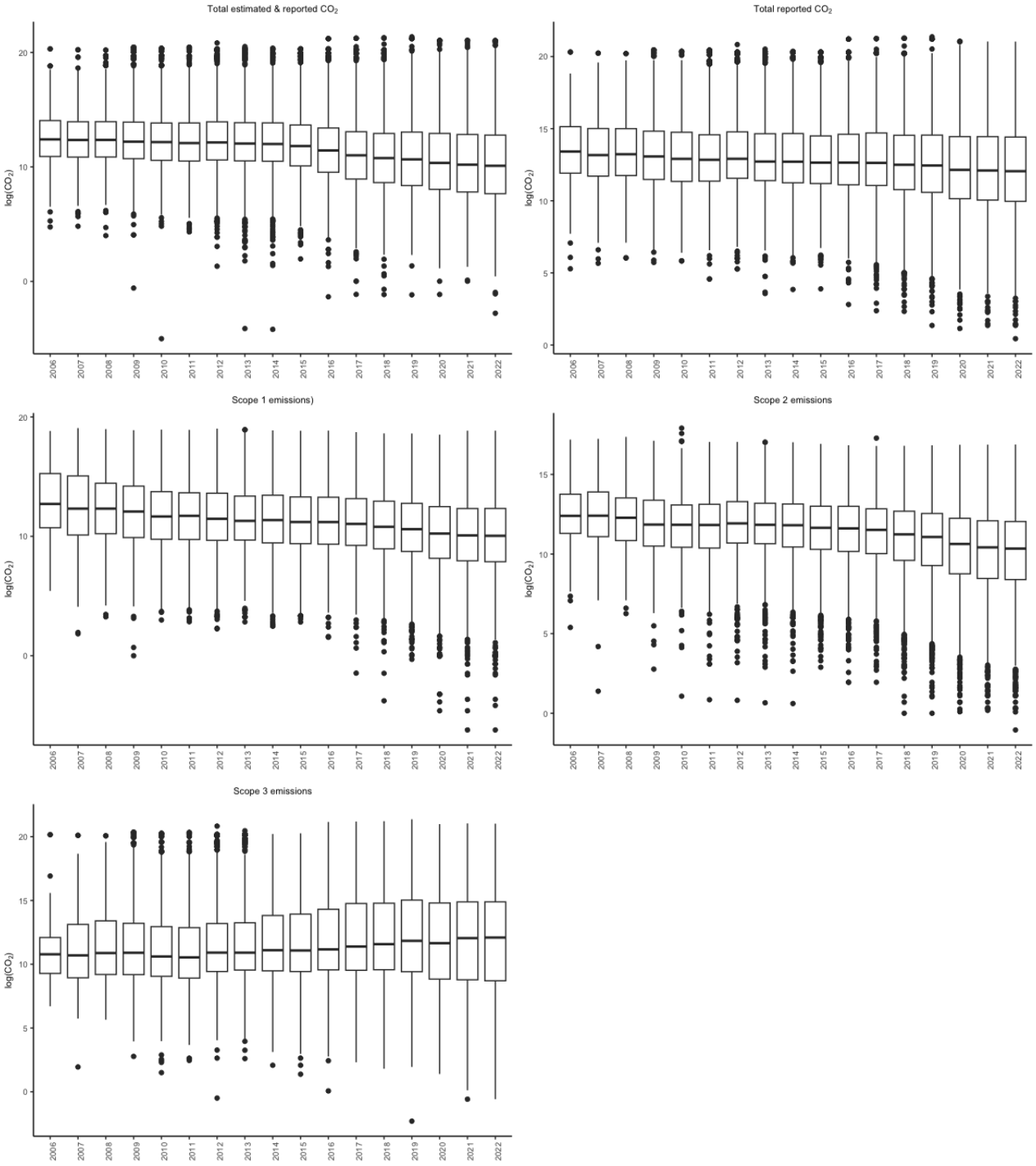
	Dependent Variable: *Δ_*CO_2 (t-s, t) based on total estimated and reported emissions					
	(1)	**(2)**	**(3)**	**(4)**	**(5)**	**(6)**
	s = 1	**s = 2**	**s = 3**	**s = 4**	**s = 5**	**s = 6**
Results from Azar et al. (2021)						
Δ_Big3_hldg (t-s-1, t-1)	-0.78*	-1.42.	-2.68*	-4.07*	-3.81.	-5.14*
	(-2.08)	(-1.82)	(-2.16)	(-2.18)	(-1.76)	(-2.11)
Δ_NonBig3_hldg (t-s-1, t-1)	0.20*	0.07	-0.34	-0.13	-0.65*	-1.48
	(2.17)	(0.44)	(-0.73)	(-0.53)	(-2.02)	(-1.58)
Results using total estimated and reported emissions 2014-2022						
Δ_Big3_hldg (t-s-1, t-1)	0.11	0 .00	0.13	0.06	0.12	0.18
	(0.19)	(-0.08)	(0.37)	(0.2)	(0.15)	(0.37)
Δ_NonBig3_hldg (t-s-1, t-1)	-2.68	-1.58	-1.20	-1.10	-4.03	-0.13
	(-0.47)	(-0.58)	(-0.50)	(-0.39)	(-0.44)	(-0.02)
Controls	Y	Y	Y	Y	Y	Y
Firm FE	Y	Y	Y	Y	Y	Y

Appendix 7 Boxplots of Variation by Fixed Effect Category

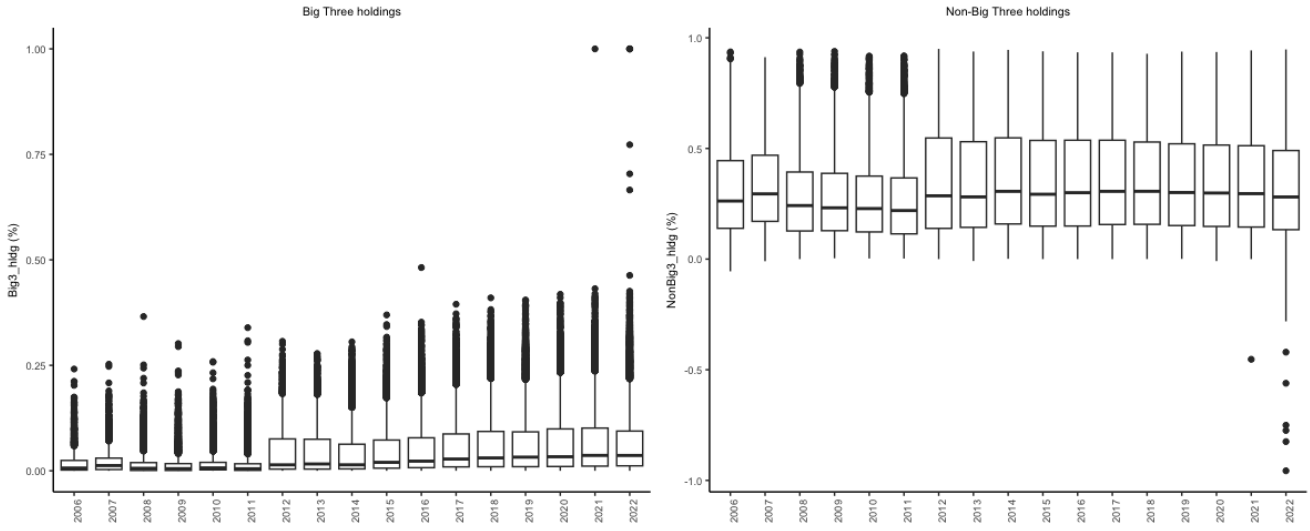
6.4 Variation by year

Figure 5 Variation in log(CO_2) and *Big3_hldg* by Year. These tables show the variation of different specifications of log(CO_2) and *Big3_hldg* displayed as boxplots. The middle line shows the median, the box is the 0.25 and 0.75 quartiles, the whiskers are the values that are at maximum 1.5 the interquartile distance and the black dots show extreme values.

Panel A. Variation in log(CO_2) by Year



Panel B. Variation Big Three and Non-Big Three holdings by Year



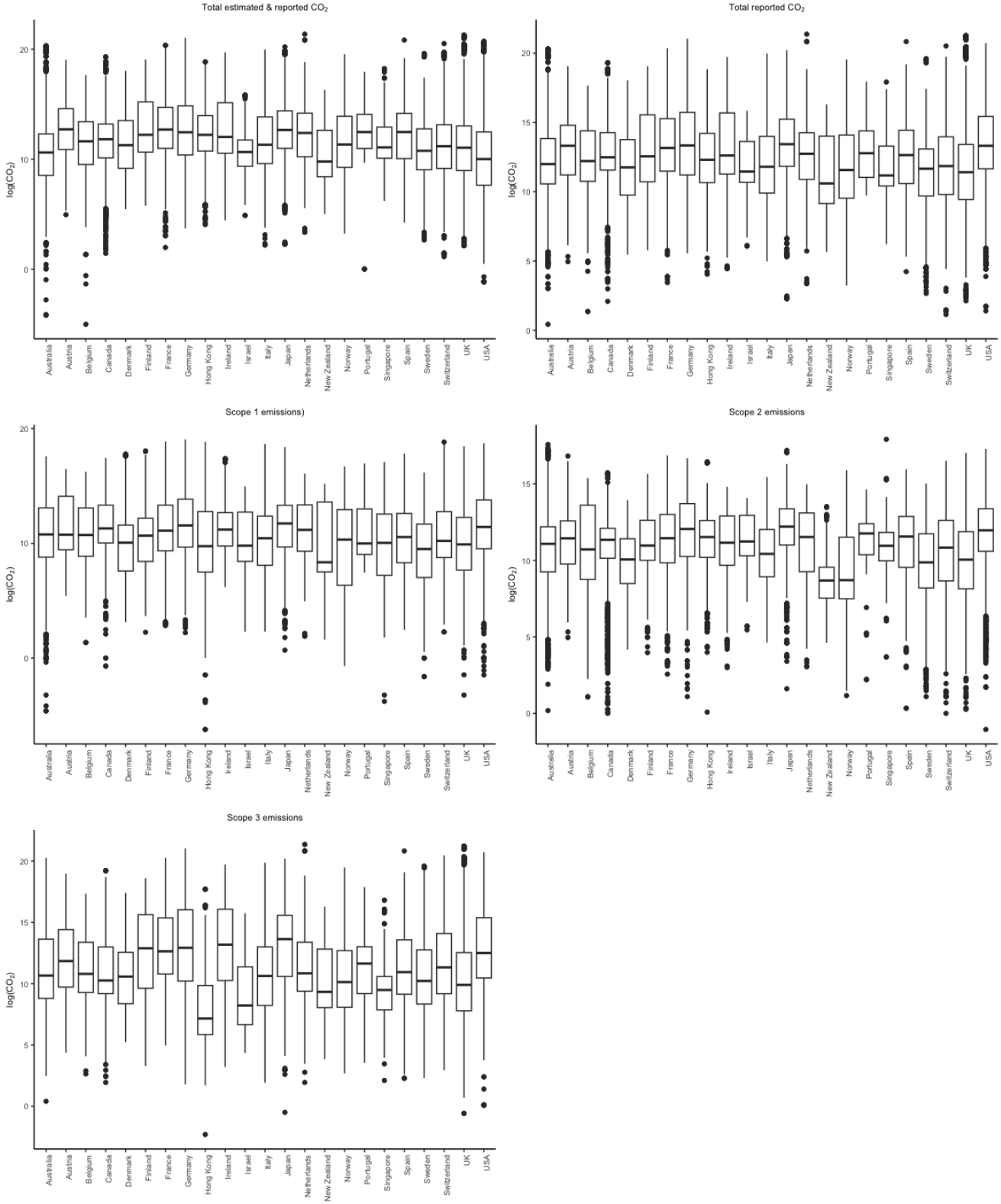
6.5 Variation by firm

There exists a lot of variation by firm. We have chosen not to display these boxplots.

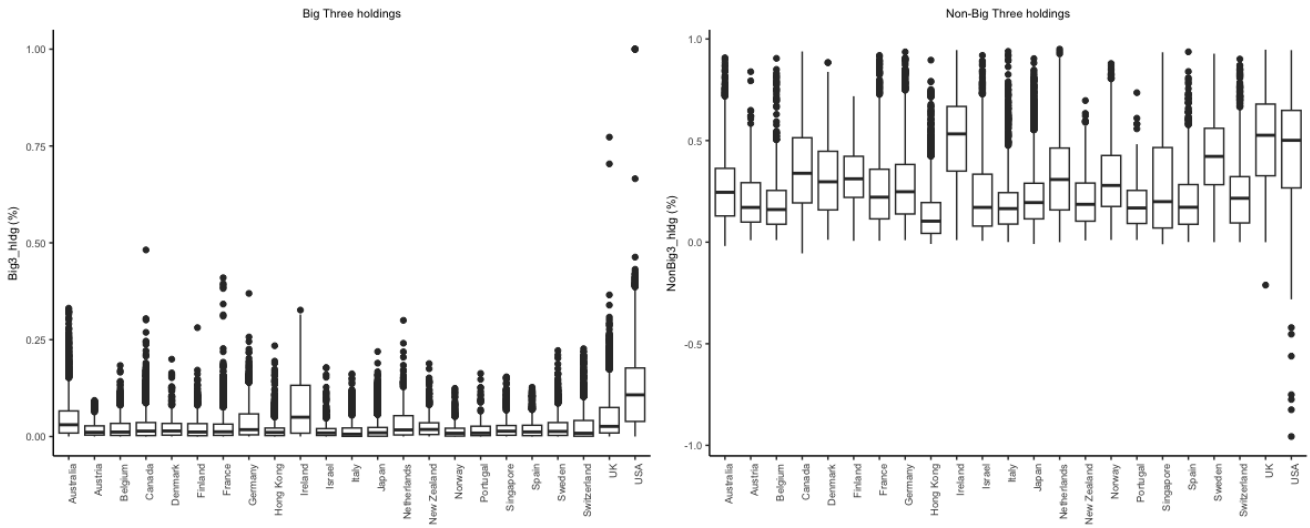
6.6 Variation by country

Figure 6 Variation in log(CO_2) and *Big3_hldg* by Year. These tables show the variation of different specifications of log(CO_2) and *Big3_hldg* displayed as boxplots. The middle line shows the median, the box is the 0.25 and 0.75 quartiles, the whiskers are the values that are at maximum 1.5 the interquartile distance and the black dots show extreme values.

Panel A. Variation in log(CO_2) by Country



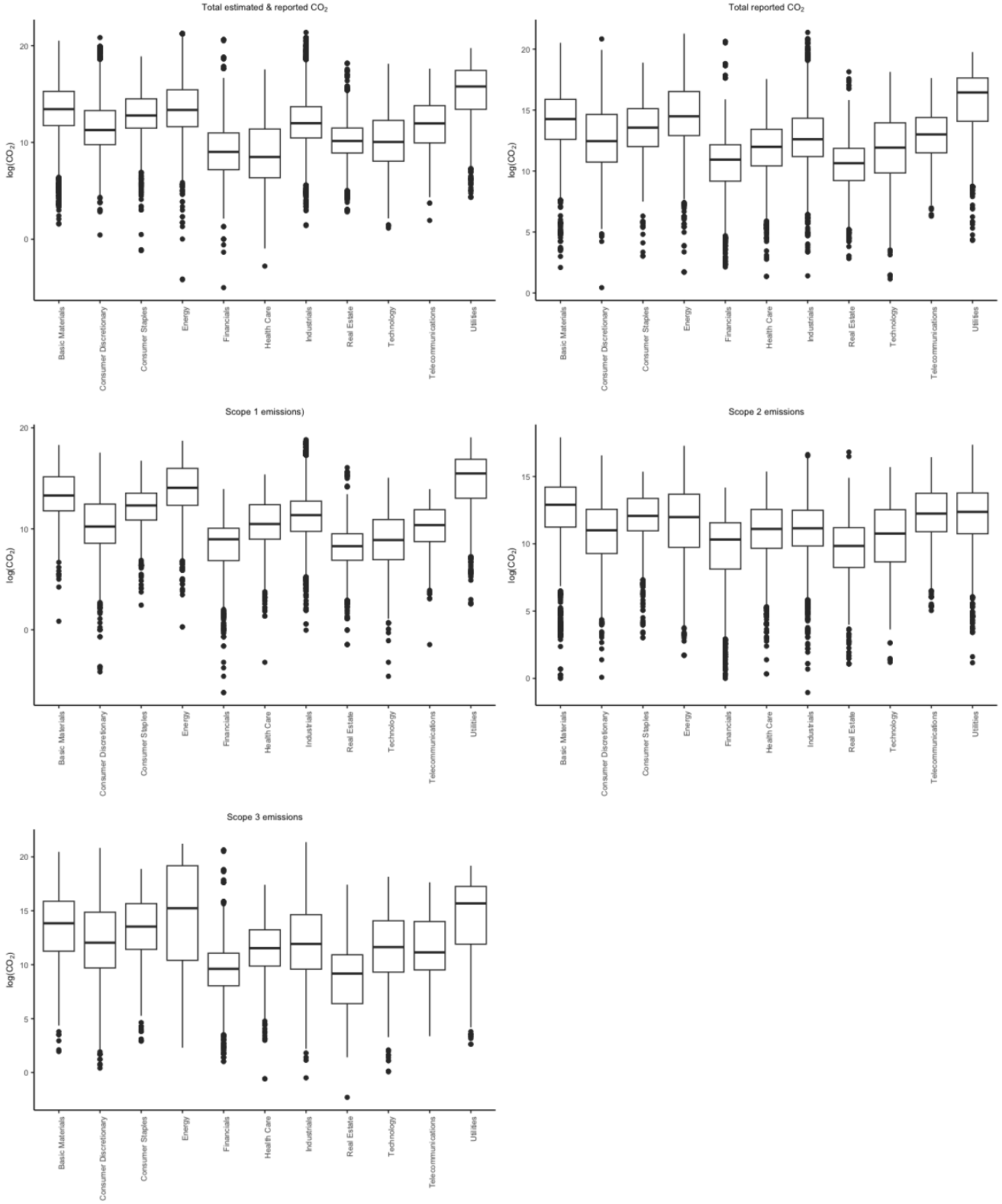
Panel B. Variation Big Three and Non-Big Three holdings by Country



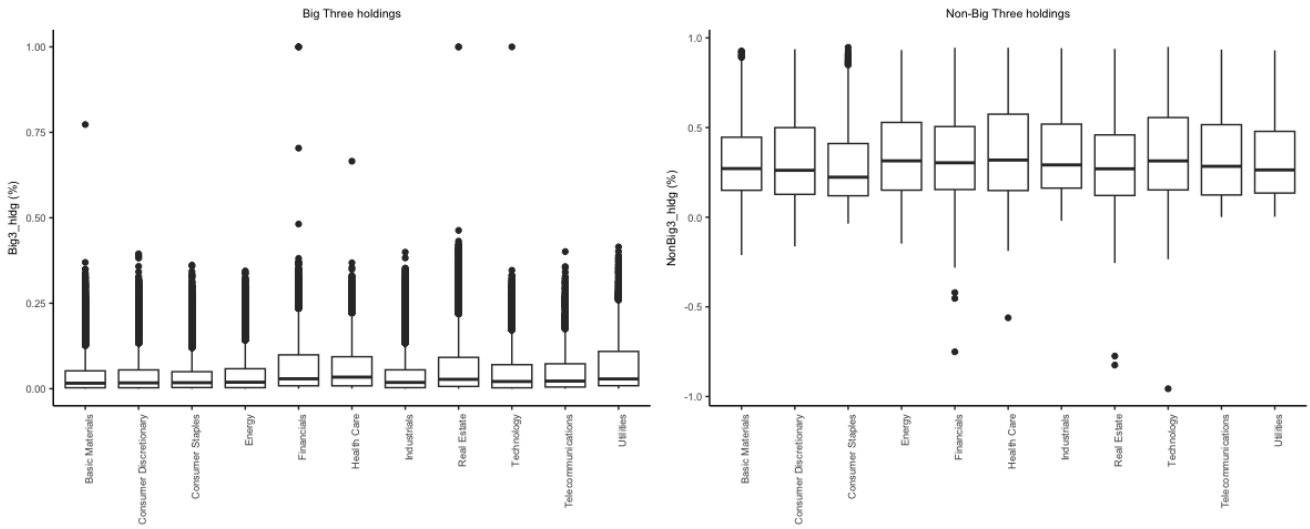
6.7 Variation by industry

Figure 7 Variation in log(CO_2) and *Big3_hldg* by Industry. These tables show the variation of different specifications of log(CO_2) and *Big3_hldg* displayed as boxplots. The middle line shows the median, the box is the 0.25 and 0.75 quartiles, the whiskers are the values that are at maximum 1.5 the interquartile distance and the black dots show extreme values.

Panel A. Variation in log(CO_2) by Industry



Panel B. Variation Big Three and Non-Big Three holdings by Industry



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