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The Big Three and corporate carbon emissions around the world ☆

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ABSTRACT

This paper examines the role of the "Big Three" (i.e., BlackRock, Vanguard, and State Street Global Advisors) on the reduction of corporate carbon emissions around the world. Using novel data on engagements of the Big Three with individual firms, we find evidence that the Big Three focus their engagement effort on large firms with high CO_2 emissions in which these investors hold a significant stake. Consistent with this engagement influence being effective, we observe a strong and robust negative association between Big Three ownership and subsequent carbon emissions among MSCI index constituents, a pattern that becomes stronger in the later years of the sample period as the three institutions publicly commit to tackle Environmental, Social, and Governance (ESG) issues.

1. Introduction

This paper studies the role of the "Big Three" (i.e., BlackRock, Vanguard, and State Street Global Advisors) on the reduction of carbon emissions around the world. In

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recent years, there has been an increasing popular demand that these large investors pressure the companies in their portfolios to curb their greenhouse gas (GHG) emissions, and the leaders of the Big Three have made public statements about their intention to do so.[1] However, whether the effort of the Big Three to reduce corporate carbon emissions is meaningful and/or effective remains an open empirical question.

Our analysis focuses on the Big Three to shed light on the recent debate about the role of these investors in the economy (Bebchuk and Hirst, 2019b; Coates, 2019; Fisch et al., 2020). The current interest in the Big Three responds to the unique combination of characteristics of these investors. The first of these characteristics is their size; they manage an enormous (and growing) amount of investments. While widely diversified, the large monetary value of the pool of assets managed by the Big Three often results in large stakes in their portfolio firms, which makes them likely pivotal voters (Bebchuk and Hirst, 2019b; Griffin, 2020). This gives the Big Three an influential role and facilitates their engagement with portfolio companies (Fichtner et al., 2017; Fisch et al., 2020). The second distinctive characteristic of the Big Three is that most of the investment vehicles sponsored by these investors are passively managed index funds and exchange-traded funds (ETFs).

Beyond possible altruistic reasons, the Big Three could have several economic incentives to engage with firms on environmental issues. One potential motivation is that these large investors believe that reducing CO_2 emissions increases the value of their portfolio. As suggested by survey evidence (Krueger et al., 2020), a nontrivial number of institutional investors believe climate risks have financial implications for their portfolio firms and the risks have already begun to materialize, particularly regulatory risks. The validity of this concern is supported by recent empirical research on the pricing implications of climate risk.[2]

The Big Three could also push firms to reduce CO_2 emissions to attract or retain investment clients that are sensitive toward environmental concerns (Barzuza et al., 2021). As explained by prior literature, prosocial behavior has several sources: (i) altruism, (ii) direct financial incentives, (iii) building social image, and (iv) social pressure (e.g., Ariely et al., 2009; Lacetera and Macis, 2010; DellaVigna et al., 2012). Given the recent proliferation of socially responsible investing, being perceived as environmentally conscious could help the Big Three to attract investors' money.

To empirically analyze the potential effect of the Big Three on corporate carbon emissions around the world, we use two novel data sets. We obtain carbon emission data for a wide cross-section of firms between 2005 and 2018. We complement these data with information on Big Three engagements with individual firms, which we hand-collect from recent public disclosures of these fund sponsors. Our data indicate that, on average, these large funds engage annually with a number of firms (e.g., from 7/1/2018 to 6/30/2019, BlackRock held personal meetings with directors and executives of 1458 firms). When we explore the determinants of the probability of such engagements, we find corroborating evidence that firms with higher CO_2 emissions are more likely to be the target of Big Three engagements. We also find that the Big Three focus their engagements on large firms (i.e., firms with a potentially larger effect on global carbon emissions) and on firms in which these large investors have a more substantial stake (i.e., firms in which the Big Three are more influential).

Next, we explore whether Big Three engagements are followed by a reduction in CO_2 emissions. We start by testing whether there is an association between Big Three ownership in a given firm and that firm's CO_2 emissions. We find a negative and significant association for MSCI firms; a one standard deviation increase in Big Three holdings in a given firm is associated with a reduction of approximately 2% in corporate CO_2 emissions. The association is concentrated in cases where the Big Three hold a significant stake in a given company, namely in cases where the Big Three are likely to be more influential.

The negative relation between Big Three ownership and carbon emissions is robust to a battery of additional tests. First, we use specifications based on changes in the values of the variables. Second, we focus on non-negligible changes (more than 1% increase) on the levels of Big Three ownership. Third, we add a wide range of fixed effects, including year, industry, country, firm, country-by-year, industry-by-year, size-decile-by-year, and country-by-industry-by-year fixed effects.

We also explore cross-sectional and time-series variation in the previously documented patterns. Tellingly, we observe that the above-mentioned negative association is more pronounced for higher values of the probability that the Big Three engages with the firm on environmental issues (such probability is measured in accordance with our previous tests). Consistent with an increasing popular demand that these large investors pressure the companies in their portfolios to curb emissions, we find that the pattern is stronger in the later years of the sample period.

[1] BlackRock's vice chairman Phillip Hildebrand and global head of impact investing Deborah Winshell stated in a report by the asset manager that "[*i*] nvestors can no longer ignore climate change. Some may question the science behind it, but all are faced with a swelling tide of climate-related regulations and technological disruption" (BlackRock, 2016). More recently, BlackRock CEO Larry Fink, in his 2020 annual letter addressed CEOs and their companies stating that: "climate change is almost invariably the top issue that clients around the world raise with BlackRock […]. In the near future—and sooner than most anticipate—there will be a significant reallocation of capital" (https://www.blackrock.com/corporate/investor-relations/larry-fink-ceo-letter).

[2] Recent literature in finance highlights the importance of climate risks for institutional investors. First, some papers provide evidence that environmental policies lower downside risk (Hoepner et al., 2019; Gibson-Brandon and Krueger, 2018). Second, institutional investors can reduce overall portfolio risk by incorporating climate criteria into their investment processes (Jagannathan et al., 2018). Modern asset pricing models emphasize climate risks as a long-run risk factor (Bansal et al., 2017) and the importance of environmental pollution in the cross-section of stock returns (Bolton and Kacperczyk, 2019; Hsu et al., 2019). Archival literature corroborates these conclusions by showing that extreme weather is reflected in stock and option market prices (Kruttli et al., 2019). At the industry level, Addoum et al., (2019) show that extreme temperatures affect earnings; (Chava, 2014; Ghoul et al., 2018) show that firms can lower their cost of capital and increase value by improving their environmental policies; and (Ginglinger and Moreau, 2019) show that greater climate risk leads to lower firm leverage.

Critically, the association becomes stronger as each of the three institutions increases its commitment to deal with environmental issues (which we measure based on Big Three's public disclosures).

To further sharpen identification, we exploit the yearly reconstitution of the indexes Russell 1000 and Russell 2000. For companies that are around the 1000/2000 cutoff, the final assignment to the index is relatively random, and the inclusion in the Russell 2000 Index likely increases Big Three ownership (a number of funds sponsored by the Big Three track the Russell indexes). We find that the changes in Big Three ownership driven by the inclusion in this index are followed by lower subsequent CO_2 emissions.

Our paper contributes to the burgeoning literature on climate risk. One strand of this literature studies the effect of climate risk on firm value. For example, Bansal et al. (2017) study climate risk as a long-run risk factor, and Bolton and Kacperczyk (2019) and Hsu et al. (2019) study climate risk in the cross-section of stock returns. In contrast with the view that environmental issues are too remote and uncertain to have a meaningful economic effect, this literature generally finds substantial price and real effects of climate risk. That said, these papers also find evidence of mispricing and behavioral responses to environmental concerns.

Other recent studies examine whether and how institutions react to climate risk. Some of these papers provide empirical evidence that investors take into account climate risk considerations in their investment portfolio decisions (e.g., Hoepner et al., 2019; Gibson-Brandon and Krueger, 2018).[3] However, the evidence on how institutional investors engage with their portfolio companies on climate risk matters is relatively scant. The available evidence is limited to studies using data from a single fund (Dimson et al., 2015; Dimson et al., 2018) and survey data (e.g., McCahery et al., 2016; Krueger et al., 2020). Similar to our paper, (Dyck et al., 2019) use a wide international sample of firms and find a positive association between institutional ownership and corporate environmental scores (measured by ASSET4 E&G scores). Our study differs from this literature in that we analyze the role of the Big Three (rather than that of institutional ownership in general) on CO_2 emissions (rather than on environmental scores).[4] These are important distinctions; the Big Three have unique characteristics and play an important—yet controversial—role in the economy, and environmental scores could reflect "greenwashing" rather than actual environmental improvements.

This paper also adds to the nascent literature on large indexers. The spectacular growth of the volume of assets of these institutions in recent years has spurred a debate on the role of the Big Three in the economy (e.g., Bebchuk and Hirst, 2019b; Coates, 2019; Fisch et al., 2020). While acknowledging the advantages of index fund investing in terms of diversification and lower management fees, recent academic work has raised some concerns about the Big Three, including anticompetitive effects (Azar et al., 2016; Azar et al., 2018; Anton et al., 2018) and concerns related to pricing efficiency and trading behavior (Coates, 2019). More related to our research question, Bebchuk and Hirst (2019a) argue that index funds underinvest in stewardship and defer excessively to the preferences and positions of corporate managers. In contrast, other authors argue that fund sponsors compete not only on fees but also on returns (e.g., Fisch et al., 2020). Moreover, recent research suggests that passive investors have meaningful monitoring incentives when it comes to cross-cutting issues such as sustainability and certain aspects of corporate governance in which large investors can exploit economies of scale and that do not require a significant investment in firm-specific monitoring (e.g., Appel et al., 2016; Gormley et al., 2020).[5]

We add to this important debate by studying a dimension of high social relevance: the reduction of carbon emissions. This dimension of the debate is not without controversy; for example, the fact that the Big Three have provided relatively little voting support to shareholder proposals related to climate issues is sometimes interpreted as evidence that these investors do not contribute to the global effort to reduce corporate carbon emissions (see Online Appendix OB for a detailed discussion).

The evidence in this paper should also be relevant for those who view GHG emissions as a market failure (Stern, 2008; Stavins, 2011). Since a full-scale regulatory solution to the emissions externality problem faces severe coordination frictions across countries, corporate governance is regarded as an alternative way of addressing climate change. In particular, large diversified institutions are increasingly viewed as catalysts in driving firms to reduce their carbon emissions (Andersson et al., 2016; OECD, 2017).

The remainder of the paper is organized as follows. In Section 2, we develop the hypothesis that the Big Three can induce firms to reduce carbon emissions. In Section 3, we describe the sample construction and measurement choices. In Section 4, we analyze engagements of the Big Three with firms. Results on the association between the Big Three and carbon emissions are discussed in Section 5. In Section 6, we conduct additional tests. Section 7 concludes.

[3] Hoepner et al. (2019) and Gibson-Brandon and Krueger (2018) show that better environmental policies are related to lower downside and overall portfolio risk. In a similar spirit, Jagannathan et al. (2018) show that investors can reduce portfolio risk by incorporating climate criteria into their investment processes, and Ramelli et al. (2018) provide evidence that investors react to political events related to firms' climate strategies.

[4] Three other recent papers empirically analyze the Big Three. Bebchuk and Hirst (2019b) provide descriptive evidence of the growth of these institutions during recent years. Fichtner et al. (2017) analyze proxy vote records and find that the Big Three use coordinated voting strategies and hence follow a centralized corporate governance strategy, which generally consists in voting with management. Gormley et al. (2020) focus on the role of Big Three on gender diversity.

[5] In light of this research, Online Appendix OA provides a detailed discussion on the Big Three's incentives to engage with portfolio firms.

2. Hypothesis development

2.1. The Big Three's incentives to reduce carbon emissions

Corporate externalities such as CO_2 emissions are commonly viewed as societal costs that are caused by corporations but are not internalized by firms' shareholders and managers. Under this view, shareholders (and managers) would have no incentive to reduce corporate externalities.

However, it is plausible that large and diversified asset managers—unlike undiversified ones—internalize at least some of the costs from CO_2 emissions and therefore would benefit from a reduction in CO_2 emissions across portfolio firms. Theoretically, this idea is supported by early models showing that diversified shareholders could internalize some externalities from their portfolio companies (e.g., Hansen and Lott, 1996; Hartford, 1997). These externalities potentially include both direct damages to firm assets from climate change and more indirect costs such as social stigma and the risk that public environmental concerns trigger regulation. In the case of the effect of CO_2 emissions on the value of indexers' portfolios, this possibility is supported by recent literature showing that climate change can affect firm valuations (Brinkman et al., 2008). These institutions' direct financial incentives to promote value-increasing strategies can be quite high in spite of the low percentage fees, because of the large dollar value of their investments (e.g., Lewellen and Lewellen, 2020). Thus, to the extent that large indexers hold stable portfolios of a large number of corporate securities, if corporate emissions contribute significantly to climate-related systematic risk, reducing carbon emissions can make large indexers better off.

Recent survey evidence on investors' attitude toward climate risk provides support for the idea that investors believe that reducing carbon emissions pays off. For example, based on a survey of a large number of investment managers, (Krueger et al., 2020) conclude that institutional investors believe climate risks have financial implications for their portfolio firms and that the risks have already begun to materialize.

Even if index managers did not believe that climate risk alone has a substantial impact on portfolio value, the Big Three could push for a reduction of CO_2 emissions to attract or retain investment clients that are sensitive toward environmental concerns. Lack of response to the social demand that the Big Three play a role in the reduction of carbon emissions could result in outflows from the Big Three to asset managers perceived to be more socially and environmentally responsible. Indeed, recent evidence suggests investors value sustainability beyond pecuniary motives (e.g., Riedl and Smeets, 2017; Hartzmark and Sussman, 2019) and that mutual funds compete for climate-conscious investment flows (Ceccarelli et al., 2020).

The incentives of the Big Three to reduce CO_2 emissions could be called into question on the grounds that most of the investment vehicles sponsored by the Big Three are passively managed, and passive investors have relatively weak incentives to invest in firm-specific monitoring (Bebchuk and Hirst, 2019a). This concern is seemingly supported by the relatively modest number of Big Three employees exclusively focused on stewardship. We offer some considerations in this regard. To begin, there is an ongoing debate about the impact of index investors, and several recent papers suggest that the net benefit from monitoring could be greater than suggested by the previous criticisms (e.g., Appel et al., 2016; McCahery et al., 2016; Fisch et al., 2020). Moreover, according to a recent report by Morningstar, the top active fund families have even smaller stewardship teams, report fewer private engagements, and exhibit voting behavior similar to that of the Big Three (Morningstar, 2017). Recent research also suggests that passive investors have meaningful incentives to monitor cross-cutting issues such as sustainability and certain aspects of corporate governance, as monitoring these issues requires relatively less firm-specific research (i.e., it is less costly) than monitoring mergers and acquisitions or board membership (e.g., Appel et al., 2016; Gormley et al., 2020). Finally, the stewardship team is larger than it might seem at first sight, as this team works in conjunction with thousands of fund managers around the world. A significant number of these investment professionals are in charge of active funds and can thus provide valuable feedback on portfolio firms (see Online Appendix OA for a more detailed discussion on the monitoring costs and benefits of the Big Three).[6]

2.2. How can the influence of the Big Three result in lower CO2 emissions?

Shareholders usually influence firm behavior through three mechanisms: selling (or not buying) the stock, exercising voting rights, and engaging with management and voicing their concerns. While index funds usually do not "vote with their feet" (they hold the stock of the company as long as the firm is included in the index tracked by the fund), large indexers can be highly influential on corporate decision-making.[7] The reason is that these large institutions often hold a substantial percent of the shares of their portfolio companies and can thus be pivotal voters in control contests, activist campaigns, and mergers (Coates, 2019). Moreover, the support of the Big Three can be important in director elections.[8] To the extent

[6] The Big Three offer a large number of actively managed funds. For example, 27% of BlackRock's assets under management (i.e., USD $2 trillion) is in actively managed funds (BlackRock, 2019a), which makes BlackRock one of the largest active asset managers on the market. To facilitate coordination among fund managers and the investment stewardship team, BlackRock has built a proprietary database, Aladdin® Research, where employees introduce the key points from any engagement with portfolio companies (BlackRock, 2020). BlackRock refers to this notion of cooperation on firm monitoring as "stewardship ecosystem" (BlackRock, 2020).

[7] In the third quarter earnings release in 2019 BlackRock stated, "of the assets we manage, 50% are equity assets, and of these, 92% are index and 8% active. The index assets closely track market indexes created by others, which means whether we like a company or not—including its management, its strategy, its products—we will still hold it in these portfolios. This is quite different than actively managed portfolios that can express displeasure by 'voting with their feet' and selling the stock. Given this long-term perspective, our investment stewardship activities are focused on maximizing long-term shareholder value" (see https://ir.blackrock.com/files/doc_news/archive/4a1e3da1-e31d-4295-a0e8-96eed78aeef2.pdf).

[8] While directors usually obtain a large majority of votes, losses in voting support undermine directors' professional standing and induce direc-

that these situations are relatively common, disregarding explicit requests from the Big Three can be costly for firm managers and directors.

The Big Three could also exert influence over managers without explicit engagements. By making public statements, the Big Three can communicate their preferences to thousands of portfolio companies without having to engage with each company's management individually. For example, BlackRock often sends letters to each of the most carbon-intensive companies in their portfolio asking them to disclose climate risks (BlackRock, 2018). Firms' managers and/or directors could respond to such public demands to obtain the support of Big Three in key voting items. For example, according to Condon (2020), at Exxon's 2017 annual meeting, the company's largest shareholder, BlackRock, voted against the reelection of two board members in protest of a "nonengagement" policy that precluded directors from talking to shareholders about the company's strategic response to climate change. Following the vote, Exxon reconsidered its opposition to climate risk disclosure and permitted directors to meet with shareholders going forward.

Furthermore, the Big Three can indirectly induce a reduction in CO_2 emissions by promoting governance structures that make firms more responsive to investors (e.g., Gordon and Pound, 1993; Carleton et al., 1998; Appel et al., 2016). These governance structures could make corporate managers more responsive to the recent demands of all investors (not just the Big Three) to take climate risks seriously.

While reducing carbon emissions is usually costly, firms could curb emissions through relatively efficient and nondisruptive product and process improvements. In particular, companies could rebalance their product mix based on their carbon emissions and/or reduce the amount of input materials (e.g., Starbucks recently introduced a strawless cold drink lid). In addition, firms could improve their logistics to reduce transportation-related emissions, switch energy sources (e.g., by moving to cleaner sources of energy such as natural gas and wind), and/or implement CO_2 capture and storage technologies (e.g., Chevron uses such technologies to capture the emissions they flare when converting the natural gas to liquefied natural gas). Finally, firms could improve end-user energy efficiency (e.g., by building weathering, turning down heating, using LED light bulbs, and reducing redundant trips).

3. Data, sample, and measurement

3.1. Data and sample construction

Our initial sample includes the universe of public firms covered by Trucost (a commercial provider of corporate carbon emission data) in the period between 2005 and 2018.[9] Trucost is a widely used source of firm carbon emission data for the corporate sector (e.g., MSCI and S&P use Trucost data in their indexes) and for international organizations such as UNEP FI (i.e., the United Nations Environment Program Finance Initiative). Trucost covers a wide cross-section of firms around the world (since 2005, this vendor has typically covered an average of 5046 firms per year, which represent approximately 80% of global market capitalization). Trucost collects carbon emission data from publicly available sources. When a covered firm does not publicly disclose its carbon emissions, Trucost estimates a firm's annual carbon emissions based on an environmental profiling model. Appendix B provides a description of the process followed by Trucost to assess corporate carbon emissions and an example of the computation of a firm's total CO_2 emissions.

Several sample countries have introduced regulations that enhance the reliability of the emissions reported by firms to Trucost, either by mandating strict guidelines and/or by recommending independent verification of the reported emissions.[10] Corroborating the reliability of these data, prior research finds a correlation of 0.99 among the direct CO_2 emissions reported by five providers, namely CDP, Trucost, MSCI, Sustainalytics, and Thomson Reuters (Bolton and Kacperczyk, 2019).

We obtain data on institutional ownership from the FactSet/LionShares database. FactSet/LionShares gathers institutional ownership for US equities from mandatory filings with the Securities and Exchange Commission. For stocks traded outside the US, FactSet/LionShares gathers institutional ownership data from national regulatory agencies and stock exchange announcements as well as direct disclosures of mutual funds, mutual fund industry directories, and company proxies and annual reports. We obtain accounting and market data from Compustat Global and Datastream/WorldScope. These data sets provide stock price, balance sheet, and income statement information for a large number of international firms.

Table 1 outlines the sample selection procedure. As shown in Table 1, we depart from 55,118 firm-year observations in the Trucost data set. To be included in the sample, we require nonmissing institutional ownership and financial data. We also require the firm to be incorporated in one of the 24 countries covered by the MSCI World Index.[11] The resulting sample consists of 42,193 firm-year

tors to take corrective actions (see Cai et al., 2009; Fischer et al., 2009). In particular, top managers and directors could lose investors' voting support if they fail to address environmental concerns. For example, in his 2020 letter, Larry Fink, CEO of BlackRock states that "we will be increasingly disposed to vote against management and board directors when companies are not making sufficient progress on sustainability-related disclosures and the business practices and plans underlying them."

[9] Carbon emission data are rarely available before 2005. The Carbon Disclosure Project (CDP) launched the first climate change survey in 2006, thus enabling companies to provide standardized disclosure of emission information.

[10] For example, the "Grenelle de l'environnement" in France was addressed to all companies with over 500 employees in 2013. The French regulation states that a company's report must be subject to verification by an independent third party (appointed by the executive director or chief executive). In the UK, the reporting of direct and certain indirect emissions has been mandated from 2013, although verification is not mandatory.

[11] To mitigate the distorting effects of outliers, we also exclude observations with extreme regression diagnostics (studentized residuals exceeding 2.5). This outlier screen removes 0.8% of the available firm-years in the MSCI subsample and 1% of the available firm-years in the non-MSCI subsample.

Table 1
Sample construction
This table describes the procedure to construct our sample.

Steps of the sample selection procedure:	# firm-years	# distinct firms
Firms covered by Trucost from 2005 to 2018	55,118	9,973
less observations missing institutional ownership information	44,252	8,109
less observations missing accounting and market data	42,193	7,751
Final sample:		
MSCI constituents	19,224	2,104
Other firms	22,969	5,647

observations, 19,224 observations corresponding to constituents of the MSCI World Index and 22,969 observations corresponding to firms that are not included in this index.

3.2. Measurement choices and descriptive statistics

To measure a firm's annual carbon emissions, we define Log (CO_2) as the logarithm of the firm's annual GHG emission measured in equivalents of metric tons of CO_2. The variable measuring Big Three ownership, *Big3_hldg*, is defined for each firm-year as the fraction of the firm's equity held by the Big Three in that year. For each firm-year, we compute Big Three ownership at the parent level; that is, we aggregate the holdings of all mutual funds of BlackRock, Vanguard, and State Street Global Advisors in that firm-year. Most of the Big Three's investments in our sample firms are held in index funds (out of the average of 4.8% of shares owned by the Big Three in the MSCI firms, 4% are owned by index funds managed by the Big Three). *NonBig3_hldg* is the fraction of the firm's equity held by institutional investors other than the Big Three.

Our tests include a vector of firm-level control variables, *Controls*, defined as follows. Size is the logarithm of total assets. We include this variable to control for the volume of the firm's business activity as well as for potential public pressure over its environmental impact. Log *(BM)* is the logarithm of the book-to-market ratio (book value of equity divided by market value of equity). We include this variable to control for the firm's growth opportunities. We also include a measure of past performance, *ROA*, defined as net income scaled by total assets. *Leverage* is computed as the sum of the long-term debt and the debt in current liabilities over firm's total assets. *PPE* is the ratio of property, plant, and equipment over the firm's total assets. We include these two variables to measure credit constraints; more leveraged firms have to cope with regular cash outflows, which could preclude financing of environmentally beneficial investments. Conversely, pledgeable assets support more borrowings, which in turn allow for further investment in pledgeable assets. All continuous control variables are winsorized at the 1 and 99 percentiles to mitigate the effect of outliers. Standard errors are double clustered at the firm and year level (in Section OD.2 of the Online Appendix, we repeat the tests using alternative ways of clustering standard errors).

Table 2 presents descriptive statistics for the variables used in our main tests. As shown in Table 2, the average ownership by the Big Three among MSCI firms is 4.8%, with a standard deviation of 4% and a 75th percentile of 7%. This suggests that the Big Three have substantial voting power in a number of companies around the world (Fichtner et al., 2017). Total institutional ownership (i.e., the sum of *Big3_hldg* and *NonBig3_hldg*) is 45% on average, a value that is in line with prior studies on institutional ownership around the world (Bena et al., 2017). Table 2 also shows that our sample includes a wide variety of firms in terms of size, leverage, and profitability (Panel A) as well as country of origin and industry affiliation (Panels B and C).

4. Engagements of the Big Three with portfolio firms

To gauge whether the Big Three can induce companies to reduce carbon emissions, we start by analyzing these large investors' engagements with the firms in their portfolios. The Big Three have recently started to disclose comparable detailed data on private engagements with their portfolio firms in investment stewardship reports (ISR).[12]

According to the narrative in the ISRs, most engagements go beyond sending a letter to the firm. For example, BlackRock's ISR states that the fund's investment stewardship department had "substantive dialogue with the companies listed as engaged firms." The ISR also states that the fund "engages companies for the following reasons: (1) to ensure that BlackRock can make well-informed voting decisions; (2) to explain its voting and governance guidelines; (3) to convey its thinking on long-term value creation and sound governance practices."

We manually collect engagement information from the most recent ISRs published by the Big Three. We disregard engagements by letters and include only comprehensive engagements via calls and in-person meetings. The length of the period covered by the ISR exhibits some variation across the three investors. BlackRock's (2019) ISR includes engagements from 7/1/2018 to 6/30/2019. Vanguard's 2019 ISR includes engagements from 7/1/2018 to 12/31/2018. State Street's 2019 ISR includes engagements from 1/1/2018 to 12/31/2018. Vanguard and State Street classify engagements into broad categories according to the

[12] Before 2018, the disclosure of engagement data was scarce and different across the three institutions. For example, BlackRock limited its disclosure of engagements to summary statistics aggregated by region. In 2015, for instance, BlackRock reported that the fund conducted 90 direct engagements with its portfolio companies on environmental issues, but the identity of the companies engaged was not revealed (see 2015 corporate governance and responsible investment report https://www.blackrock.com/corporate/literature/whitepaper/blk-cgri-2015-annual-vande-statistics-report.pdf).

Table 2
Descriptive statistics

This table reports descriptive statistics for the variables and observations used in our tests. The sample spans from 2005 to 2018 and includes 19,224 firm-year observations in the MSCI subsample and 22,969 firm-year observations in the non-MSCI subsample. Panel A presents descriptive statistics for the main variables used in our tests. Panel B presents descriptive statistics by country. Panel C presents descriptive statistics by industry affiliation. Variables are defined in Appendix A.

Panel A. Descriptive statistics of key variables

	MSCI firms					Non-MSCI firms				
	Std dev	P25	Median	Mean	P75	Std dev	P25	Median	Mean	P75
Log(CO_2)	1.81	13.01	14.18	14.25	15.52	1.99	10.32	11.74	11.65	13.00
Big3_hldg	0.040	0.016	0.035	0.048	0.070	0.052	0.005	0.018	0.042	0.062
BlackRock_hldg	0.013	0.008	0.015	0.018	0.024	0.024	0.001	0.006	0.018	0.026
StateStreet_hldg	0.008	0.001	0.005	0.008	0.012	0.006	0.000	0.001	0.004	0.004
Vanguard_hldg	0.024	0.004	0.011	0.022	0.035	0.027	0.000	0.008	0.020	0.029
NonBig3_hldg	0.288	0.147	0.309	0.405	0.695	0.275	0.095	0.250	0.334	0.545
Controls:										
Size	1.51	8.49	9.37	9.56	10.45	1.5	6.02	6.96	7.01	7.91
Log(BM)	0.83	−1.24	−0.74	−0.83	−0.28	0.92	−1.14	−0.57	−0.67	−0.05
ROA	0.06	0.02	0.04	0.05	0.08	0.1	0.01	0.04	0.03	0.07
Leverage	0.17	0.11	0.23	0.24	0.35	0.19	0.04	0.18	0.21	0.33
PPE	0.24	0.07	0.21	0.27	0.42	0.24	0.05	0.19	0.25	0.38

Panel B. Sample distribution by country

	MSCI firms					Non-MSCI firms				
	# obs.	% obs.	# firms	Mean CO_2 (millions tons)	Mean Big3_hldg	# obs.	% obs.	# firms	Mean CO_2 (millions tons)	Mean Big3_hldg
Austria	105	0.5	14	8.00	0.02	123	0.5	23	0.49	0.02
Australia	835	4.3	95	4.21	0.03	1,367	6.0	288	0.26	0.02
Belgium	146	0.8	18	5.20	0.02	125	0.5	32	1.08	0.02
Canada	1,019	5.3	116	4.06	0.03	976	4.2	255	0.58	0.02
Switzerland	428	2.2	50	9.18	0.03	766	3.3	143	0.59	0.01
Germany	597	3.1	67	17.09	0.03	616	2.7	134	2.41	0.02
Denmark	160	0.8	22	1.56	0.02	109	0.5	25	5.91	0.02
Spain	328	1.7	40	9.20	0.02	189	0.8	43	1.37	0.01
Finland	207	1.1	23	4.72	0.02	127	0.6	30	0.68	0.01
France	863	4.5	82	12.08	0.02	503	2.2	117	0.96	0.01
Great Britain	1,252	6.5	158	6.00	0.03	3,048	13.3	404	0.36	0.02
Greece	48	0.2	10	9.23	0.01	85	0.4	16	0.36	0.01
Hong Kong	422	2.2	54	3.97	0.02	510	2.2	80	3.47	0.02
Ireland	240	1.2	29	4.69	0.07	74	0.3	17	0.61	0.03
Israel	83	0.4	15	2.13	0.02	344	1.5	71	0.39	0.01
Italy	262	1.4	36	13.93	0.02	414	1.8	96	1.75	0.01
Japan	4,345	22.6	429	6.41	0.02	5,030	21.9	1,664	0.41	0.01
Netherlands	297	1.5	33	5.86	0.03	295	1.3	57	0.77	0.02
Norway	116	0.6	17	10.26	0.01	136	0.6	38	0.44	0.01
New Zealand	67	0.3	11	1.39	0.02	99	0.4	29	0.67	0.01
Portugal	87	0.5	11	7.29	0.01	26	0.1	8	2.26	0.01
Sweden	331	1.7	34	2.40	0.02	415	1.8	110	0.58	0.01
Singapore	328	1.7	34	4.21	0.02	193	0.8	52	0.41	0.01
US	6,658	34.6	706	8.05	0.09	7,399	32.2	1915	0.75	0.10

Panel C. Sample distribution by industry

	MSCI firms					Non-MSCI firms				
	# obs.	% obs.	# firms	Mean CO_2 (millions tons)	Mean Big3_hldg	# obs.	% obs.	# firms	Mean CO_2 (millions tons)	Mean Big3_hldg
Food	881	4.6	97	11.64	0.04	909	4.0	226	1.47	0.03
Mining and minerals	412	2.1	50	10.72	0.05	797	3.5	165	0.86	0.04
Oil and petroleum products	1,007	5.2	118	22.20	0.06	756	3.3	170	1.45	0.05
Textiles, apparel & footwear	231	1.2	25	3.07	0.04	294	1.3	86	0.42	0.03
Consumer durables	314	1.6	34	4.73	0.05	532	2.3	128	0.41	0.04
Chemicals	668	3.5	69	10.28	0.04	559	2.4	133	1.27	0.04
Drugs, soap, perfume, tobacco	977	5.1	99	3.48	0.05	767	3.3	198	0.24	0.04
Construction and constr. materials	986	5.1	113	8.34	0.04	1,556	6.8	402	0.86	0.03
Steel works, etc.	340	1.8	41	20.98	0.03	383	1.7	74	1.89	0.05
Fabricated products	108	0.6	9	4.02	0.07	235	1.0	53	0.75	0.06
Machinery and business equipment	2,071	10.8	223	3.39	0.05	2,568	11.2	600	0.41	0.04
Automobiles	562	2.9	56	11.99	0.05	573	2.5	126	2.49	0.04
Transportation	1,159	6.0	126	6.70	0.04	995	4.3	217	1.65	0.04
Utilities	1,126	5.9	109	34.03	0.06	592	2.6	112	4.67	0.06
Retail stores	1,237	6.4	130	3.77	0.05	1,457	6.3	380	0.47	0.04
Banks, insurance, and other financials	3,025	15.7	329	0.71	0.04	3,269	14.2	825	0.22	0.05
Other	4,120	21.4	476	1.93	0.05	6,727	29.3	1,752	0.28	0.04

reasons for the engagements. BlackRock simply publishes a list of firms contacted for comprehensive engagement.

We first analyze the descriptive statistics of these data. In absolute terms, we observe that, during the period covered by the ISR reports, the Big Three engage with a relatively large number of firms; BlackRock engaged with 1458 firms, State Street engaged with 686 firms, and Vanguard engaged with 356 firms. In relative terms, however, the Big Three appear to engage with a relatively small percentage of their portfolio firms: BlackRock, State Street, and Vanguard engage with 9%, 5%, and 3% of their portfolio firms, respectively. The Big Three engage much more often with firms included in MSCI World Index than with firms not included in that index; 48% (15%) of MSCI (non-MSCI) firms were targeted by the Big Three in 2018. In absolute terms, the number of engagements is also substantially higher among MSCI firms than among non-MSCI firms (625 and 275, respectively). Thus, the Big Three appear to focus their engagement efforts on the largest public firms in each country (the MSCI World Index aims to cover 85% of total market capitalization in 24 developed countries). The focus on large firms is consistent with these firms being more influential (more visible) and having a potentially stronger effect on climate change.[13]

Next, we conduct a multivariate test on the determinants of the probability that a given firm is engaged by each of the Big Three. For each of the Big Three, we construct the left hand side variable as an indicator that equals one if the firm is included in the list of engagements disclosed in 2019 ISR of one of the Big Three institutions and zero otherwise (we refer to these institution-specific variables as *Engagement_BlackRock, Engagement_StateStreet*, and *Engagement_Vanguard*, respectively).[14] We construct these variables for the cross-section of our sample firms as of the start of 2018 (i.e., the firms in the Trucost universe that meet the data requirements described in Section 3).

The right hand side variables are defined as follows. Log (CO_2) is the logarithm of GHG emissions, as previously defined. *Big3_hldg* is the fraction of the firm's shares held by funds managed by BlackRock, Vanguard, or State Street. The specification also includes a vector of controls for firm characteristics: Size, Log *(BM), ROA, Leverage*, and *PPE*, all of them as previously defined (see Section 3 and Appendix A for variable definitions). We also include an indicator for whether the firm is an MSCI constituent (*MSCI_constituent*).

Table 3 presents the results of estimating logit and OLS regressions for each of the Big Three based on the variables described above. The results reveal that the probability of Big Three engagement is higher if the target firm exhibits higher levels of carbon emissions in the previous year (the coefficient on Log (CO_2) is consistently positive and statistically significant). Table 3 also shows that, in general, the Big Three are more likely to engage with firms in which they are more influential (the coefficients on the three institutions' ownership share are generally positive and statistically significant). The association of the probability of engagement with *Size* and *MSCI_constituent* is often positive and strong, which confirms that the Big Three focus their engagement efforts on MSCI constituents. In Online Appendix OD.1, we conduct a placebo test by constructing the dependent variables in Table 3 using engagements that are not related to environmental issues. The coefficient on Log (CO_2) is no longer significant.

5. Carbon emissions and Big Three shareholdings

The previous results indicate that the Big Three selectively engage with a number of firms in their portfolio companies on environmental issues. We next explore whether higher ownership by these large investors is followed by lower levels of carbon emissions.

To study the relation between Big Three ownership and corporate carbon emissions, we estimate the following model:

$$Log\ (CO_2)_{it} = \alpha + \beta^{*}Big3\_hldg_{it\text{-}1} + \gamma^{*}NonBig3\_hldg_{it\text{-}1} + \Phi^{*}Controls_{it\text{-}1} + \tau_t + \delta_i + \varepsilon_{it}, \quad (1)$$

where *Big3_hldg, NonBig3_hldg*, and *Controls* are as previously defined (see Section 3 and Appendix A for variable definitions). Subindexes i and t refer to firm i and year t, respectively. All these independent variables are measured at the end of the prior year to avoid simultaneity bias. τ_t and δ_i denote year and firm fixed effects, respectively. When estimating this model, we distinguish between constituents of the MSCI World Index and other firms, as our results from tests of the probability of engagement (see Table 3) suggest that the Big Three focus their monitoring efforts on environmental issues in MSCI constituents.

Table 4 presents the results of this test. For the subsample of MSCI firms (i.e., columns 1–3), the coefficient on *Big3_hldg* is negative and statistically significant, consistent with the notion that ownership by the Big Three is associated with a subsequent decrease in CO_2 emissions. The negative association is robust to including year, industry, country, and firm fixed effects.[15] That is, the association holds both in the cross-section and in the time series and thus is unlikely to be confounded either by time-invariant country and industry characteristics or by the potential effect of the volume of economic activity on overall levels of CO_2 emissions. In contrast with this result, the coefficient on *NonBig3_hldg* is not statistically significant, suggesting

[13] Large firms emit the largest portion of corporate emissions. For example, in 2017 the aggregate level of total CO_2 emissions for our sample of US MSCI firms is 3698 million metric tons of CO_2 equivalent, which is around 70% of the total US CO_2 emissions (https://www.epa.gov/ghgemissions/inventory-us-greenhouse-gas-emissions-and-sinks-fast-facts).

[14] The classification of engagements across the Big Three is not homogeneous. Vanguard includes engagements on environmental issues in the "oversight of strategy and risks" category. State Street includes engagements on environmental issues in the "environmental/social" category. While BlackRock does not classify engagements into categories, environmental issues are commonly included in the agenda of BlackRock's engagements with portfolio companies (se.g., BlackRock, 2019b).

[15] We define industry affiliations using Fama-French 38 industry portfolios (https://mba.tuck.dartmouth.edu/pages/faculty/ken.french/Data_Library/det_38_ind_port.html).

Table 3
Big Three engagements with individual firms

This table presents an analysis of the determinants of the engagements of the Big Three (BlackRock, Vanguard, and State Street) with individual firms in their portfolios. The sample is from 2018 engagement data and includes 3636 firm observations. The dependent variable *Engagement_BlackRock* is an indicator variable that equals one if BlackRock engages with the firm and zero otherwise. The other two dependent variables, *Engagement_StateStreet* and *Engagement_Vanguard*, are defined in the same way for State Street and Vanguard, respectively. In the case of State Street we consider only engagements about environmental/social issues. In the case of Vanguard we consider only engagements about "oversight of strategy and risk" (which include environmental issues). The independent variables are measured at the end of the prior year. Log (CO_2) is the logarithm of the firm's total GHG emissions. *BlackRock_hldg* is BlackRock's holding in the firm, namely, the fraction of the firms' equity owned by BlackRock's mutual funds. *StateStreet_hldg* and *Vanguard_hldg* are defined in the same way for State Street and Vanguard, respectively. The control variables are defined in Appendix A. *t*-statistics are in parentheses. *, **, and *** denote significance at the 10%, 5%, and 1% levels (two-tail), respectively. Intercepts are omitted.

	Dependent variable:								
	Engagement_BlackRock			*Engagement_StateStreet*			*Engagement_Vanguard*		
	Logit (1)	*OLS* (2)	*OLS* (3)	*Logit* (4)	*OLS* (5)	*OLS* (6)	*Logit* (7)	*OLS* (8)	*OLS* (9)
Log(CO_2)	0.156***	0.022***	0.025***	0.315***	0.013***	0.009**	0.190***	0.006**	0.003
	(5.803)	(5.233)	(3.676)	(5.937)	(5.649)	(2.355)	(3.791)	(2.374)	(0.671)
BlackRock_hldg	16.890***	2.425***	2.232***						
	(8.631)	(7.414)	(5.863)						
StateStreet_hldg				57.763***	4.083***	2.107***			
				(7.382)	(8.231)	(2.944)			
Vanguard_hldg							23.363***	1.218***	−0.115
							(10.227)	(9.453)	(−0.458)
MSCI_constituent	0.752***	0.153***	0.134***	0.692***	0.029***	0.029**	0.711***	0.043***	0.045***
	(6.704)	(8.071)	(6.977)	(2.886)	(2.658)	(2.489)	(3.013)	(3.857)	(3.941)
Controls:									
Size	0.292***	0.043***	0.052***	0.365***	0.013***	0.024***	0.690***	0.026***	0.036***
	(7.360)	(6.966)	(6.288)	(4.823)	(3.715)	(5.017)	(9.188)	(7.112)	(7.278)
Log*(BM)*	−0.051	−0.009	−0.015	−0.241**	−0.016***	−0.009	−0.320***	−0.024***	−0.014**
	(−0.849)	(−0.963)	(−1.508)	(−2.298)	(−2.932)	(−1.632)	(−3.027)	(−4.294)	(−2.392)
ROA	0.114	−0.111	−0.132	1.083	−0.036	0.010	4.326***	−0.002	0.043
	(0.155)	(−1.224)	(−1.443)	(0.700)	(−0.703)	(0.180)	(2.671)	(−0.037)	(0.821)
Leverage	−0.826***	−0.139***	−0.105**	0.358	0.003	−0.004	−0.943*	−0.058**	−0.064**
	(−2.892)	(−3.165)	(−2.384)	(0.685)	(0.120)	(−0.140)	(−1.816)	(−2.264)	(−2.446)
PPE	−0.287	−0.045	−0.017	0.227	0.021	0.021	0.326	0.022	0.029
	(−1.523)	(−1.565)	(−0.516)	(0.663)	(1.264)	(1.085)	(0.992)	(1.298)	(1.490)
Country FE	NO	NO	YES	NO	NO	YES	NO	NO	YES
Industry FE	NO	NO	YES	NO	NO	YES	NO	NO	YES
Pseudo R^2/R^2	0.16	0.17	0.22	0.24	0.11	0.14	0.29	0.12	0.16
# obs.	3,262	3,262	3,262	3,286	3,286	3,286	3,323	3,323	3,323

that institutional ownership is generally not associated with a decrease in carbon emissions.

Fig. 1 analyzes whether the association between Big Three ownership and carbon emissions is concentrated in cases in which Big Three increases to the point of holding a significant stake in a given company, namely in cases in which the Big Three are likely to be more influential. In the analysis of Fig. 1, we reestimate Eq. (1) replacing *Big3_hldg* with separate indicator variables, each marking a 1% interval of *Big3_hldg* values. That is, the first indicator variable equals one if *Big3_hldg* ∈ [0%, 1%] and zero otherwise, the second indicator variable equals one if *Big3_hldg* ∈ [1, 2%] and zero otherwise, the third indicator variable equals one if *Big3_hldg* ∈ [2, 3%] and zero otherwise, and so forth. The last indicator variable equals one if *Big3_hldg* >10% and zero otherwise. We define the [0%, 1%] interval as baseline, and thus we exclude the indicator variable for *Big3_hldg* ∈ [0%, 1%]. As shown in Fig. 1, the association between Big Three ownership and CO_2 emissions becomes significant when the ownership of these investors crosses the 3,4% ownership threshold. This evidence is consistent with our conjecture that firms respond to the Big Three's requests to reduce emissions only when these investors can be pivotal in key voting items.

In addition, we offer three considerations that might help understand how the Big Three can influence firms even though these institutions usually do not hold majority stakes. First, while the Big Three might start acquiring a modest stake in a given company, this stake is likely to increase in the future (among other things, because the total volume of money invested in the mutual funds managed by these institutions is growing significantly).[16] Second, the Big Three's position on environmental matters could have spillovers on other institutional investors. For example, it is possible that some passive investors that do not have the resources to monitor governance practices follow the Big Three's policies. Moreover, some environmental activists could feel encouraged to put pressure on the firm if they observe that the Big Three are willing to support efforts to reduce emissions. Consistent with this,

[16] Bebchuk and Hirst (2019a) estimate the total inflows to the Big Three from 2009 to 2018 to be more than $3 trillion, which represent 82% of the inflows to all active and passive funds over that period. As a result, they estimate that the Big Three could cast as much as 40% of the votes in S&P 500 companies within two decades. Indeed, in August of 2019, US equity index fund assets officially surpassed their actively managed counterparts for the first time, reaching $4.27 trillion in total assets under management (Griffin, 2020).

Table 4
Big Three ownership and firms' carbon emissions

This table presents an analysis of the association between levels of Big Three ownership and levels of total carbon emissions. The sample spans from 2005 to 2018 and includes 19,224 firm-year observations in the MSCI subsample and 22,969 firm-year observations 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 metric tons of CO_2). The experimental variable, *Big3_hldg*, is the fraction of the firm's equity owned by mutual funds sponsored by BlackRock, Vanguard, or State Street. *NonBig3_hldg* is the fraction of the firms' equity owned by funds managed by institutions other than BlackRock, Vanguard, and State Street. The control variables are defined in Appendix A. Columns (1)–(3) report results corresponding to the subsample of firms that are members of MSCI World Index. Columns (4)–(6) report results corresponding to the subsample of firms that are not members of MSCI World Index. Both subsamples span the period from 2005 to 2018. Independent variables are measured at the end of the prior year. Standard errors are clustered at the firm and year level. *t*-statistics are in parentheses. *, **, and *** denote significance at the 10%, 5%, and 1% levels (two-tail), respectively. Intercepts are omitted.

	Dependent variable: Log (CO_2)					
	MSCI			Non-MSCI		
	(1)	(2)	(3)	(4)	(5)	(6)
Big3_hldg	−3.44***	−1.69**	−1.00***	−0.76	0.66	0.46
	(−5.76)	(−2.27)	(−2.83)	(−1.09)	(1.41)	(1.60)
NonBig3_hldg	−0.04	−0.12	−0.07	0.36***	0.26**	0.18**
	(−0.25)	(−0.74)	(−0.75)	(3.43)	(2.50)	(2.47)
Controls:						
Size	0.79***	0.80***	0.55***	0.81***	0.79***	0.56***
	(42.88)	(42.21)	(13.77)	(50.85)	(54.50)	(14.96)
Log*(BM)*	0.01	0.01	−0.02**	−0.06***	−0.06***	−0.05***
	(0.55)	(0.30)	(−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)	(6.30)
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	YES	YES	NO	YES	YES	NO
Industry FE	YES	YES	NO	YES	YES	NO
Year FE	NO	YES	YES	NO	YES	YES
Firm FE	NO	NO	YES	NO	NO	YES
R^2	0.75	0.75	0.98	0.73	0.74	0.98
# obs.	19,224	19,224	19,134	22,969	22,969	22,468

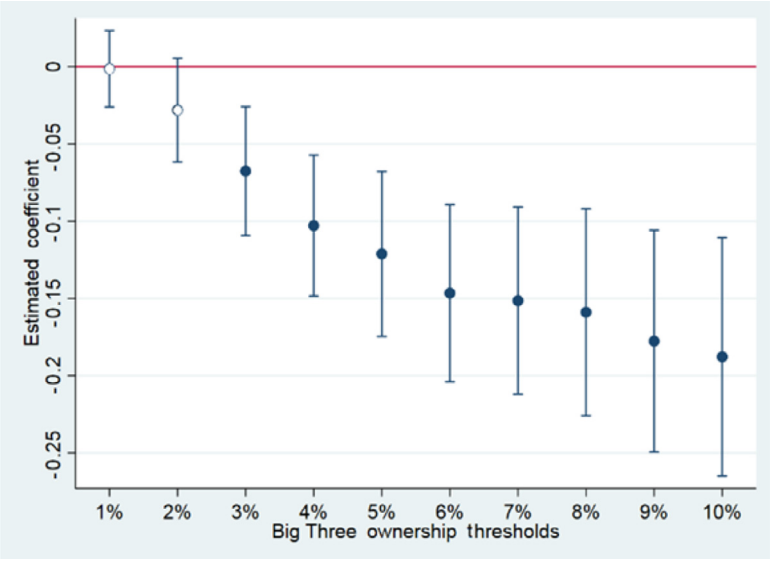

Fig. 1. Big Three ownership thresholds and carbon emissions. This figure reports the association between Big Three ownership thresholds and carbon emissions. The sample spans from 2005 to 2018 and includes 19,224 firm-year observations in the MSCI subsample. We estimate Eq. (1) but replace *Big3_hldg* with separate indicator variables, each marking a 1% interval of *Big3_hldg* values. That is, the first indicator variable equals one if *Big3_hldg* ∈ [0, 1%] and zero otherwise, the second indicator variable equals one if *Big3_hldg* ∈ [1, 2%] and zero otherwise, the third indicator variable equals one if *Big3_hldg* ∈ [2, 3%] and zero otherwise, and so forth. The last indicator variable equals one if *Big3_hldg* >10% and zero otherwise. We omit the first indicator variable, that is, the indicator variable for *Big3_hldg* ∈ [0, 1%]. It therefore serves as a benchmark and has a coefficient value of zero (and no confidence interval). The figure plots the coefficient estimates of the ten intervals together with their 95% confidence limits. The dependent variable, Log (CO_2), the sample, control variables, and fixed effects are as in Model 3, Table 4, Panel A. Filled dots (as opposed to empty dots) denote that the coefficient is statistically different from the benchmark (i.e., *Big3_hldg* ∈ [0, 1%]) (two-tailed, 10% level).

Appel et al. (2019a) provide evidence that large institutional investors are crucial for the success of hedge fund activism. Third, the influence of the Big Three could go beyond the holdings of the mutual funds sponsored by these institutions. For example, large institutions often hold corporate debt and indirectly own corporate shares through investment vehicles included in their family of investment companies (e.g., pension funds and active funds, including even hedge funds). As such, our measure of Big Three ownership is a lower bound estimate of the total amount of claims owned directly or indirectly by these institutions (a total amount that is not possible to measure across countries due to lack of available data).[17] Taken together, these considerations suggest that the percentage ownership of the Big Three in a company is likely to be a conservative estimate of the influence of these institutions in the firm.

Table 5 presents a variant of the analysis in Table 4 in which we focus on changes rather than levels of Big Three ownership. In Table 5, Panel A, we replace *Big3_hldg* with *Big3_increase*, an indicator variable that equals one if Δ*_Big3_hldg*>1%*. This variable identifies cases in which Big Three ownership increases meaningfully. Consistent with *Big3_increase* identifying cases with relatively high Big Three influence, the mean of *Big3_hldg* conditional on *Big3_increase*=1 is 8%. Consistent with Table 4, Table 5, Panel A shows that the coefficient on *Big3_increase* is consistently negative and significant across specifications.

As an alternative specification, Table 5, Panel B analyzes the association between changes in CO_2 emissions and changes in Big Three ownership for MSCI. The dependent variable is Δ_CO_2 ($t-s$, t), defined as the fractional change of CO_2 emissions from year $t-s$ to year t, that is, $(CO_{2t}-CO_{2t-s})/CO_{2t-s}$ (s=1, …, 12). In parallel to Panel A, the experimental variable is Δ*_Big3_hldg* ($t-s-1$, $t-1$), defined as the change in *Big3_hldg* from year $t-s-1$ to year $t-1$. For consistency with the previous test, we also include Δ*_NonBig3_hldg* ($t-s-1$, $t-1$), defined as the change in *NonBig3_hldg* from year $t-s-1$ to year $t-1$. The results of Table 5, Panel B show that changes in Big Three ownership are negatively associated with subsequent changes in carbon emissions for MSCI firms. Panel B also highlights that, while part of the reduction in emissions is already observable in the subsequent year, the reduction also extends to subsequent periods (e.g., firms might require more than one year to implement changes, or the changes might require some time to become effective).

To delve into the sources of our results, in Table 6 we decompose *Big3_hldg* into the holdings of each of the three institutions: *BlackRock_hldg, StateStreet_hldg*, and *Vanguard_hldg.* We also decompose *NonBig3_hldg* in three ways. First, we split *NonBig3_hldg* into *NonBig3_large* (defined as the fraction of the firm's equity held by the largest 100 institutions other than the Big Three) and *NonBig3_small* (defined as the difference between *NonBig3_hldg* and *NonBig3_large*). Second, we split *NonBig3_hldg* into *NonBig3_index* (defined as the fraction of the firm's equity held by indexers other than the Big Three) and *NonBig3_nonIndex* (defined as the difference between *NonBig3_hldg* and *NonBig3_index*).[18] Third, we split *NonBig3_Hldg* into *NonBig3_LT* (defined as the fraction of the firm's equity held by long-term investors other than the Big Three) and *NonBig3_ST* (defined as the difference between *NonBig3_hldg* and *NonBig3_LT*).[19]

As shown in Table 6, the negative association between Big Three ownership and CO_2 emissions is driven by BlackRock and State Street.[20] Table 6 also reveals that there is a negative association between CO_2 emissions and non-Big Three funds with similar characteristics: index tracking, long term, and large. That said, Table 6 also suggests that these associations are substantially lower than that between CO_2 emissions and Big Three ownership.

Tables 4–6 also present results for the subsample of nonconstituents of the MSCI World Index. While in Table 4 the coefficient on *Big3_hldg* is not statistically significant for nonconstituents of the MSCI, Table 4 shows a consistently positive coefficient on *NonBig3_hldg*. We offer two considerations to interpret this result. First, this positive association is not statistically significant in the parallel tests of Table 5. Second, Table 6 reveals that, in contrast to the results in the MSCI subsample, the positive association between CO_2 emissions and non-Big Three funds in the non-MSCI subsample is driven by funds that are not index tracking, are not long term, and are not large. As such, one possible interpretation of the positive coefficient on *NonBig3_hldg* for the non-MSCI subsample is that there is an increase in CO_2 emissions preceded by activist investors pressuring for short-term performance.

Gauging whether the potential effect of the Big Three is large enough to meaningfully contribute to the worldwide objective of reducing carbon emissions is an extremely ambitious task that exceeds the scope of this paper. With this caveat in mind, we provide some guidance to interpret our results. In Table 4, the magnitude of the coefficient on *Big3_hldg* ranges from −3.44 to −1.00, depending on the specification. A coefficient of −1.00 suggests that a

[17] Nonetheless, we also note that these other investment companies related to the Big Three act independently in environmental, social, and governance (ESG) matters as their investment strategy could differ from that of the mutual funds sponsored by the corresponding investment family.

[18] To identify index funds we use the variable "style" provided by FactSet. However, the investment style variable is available only for 48% of funds in our sample; therefore, we augment the investment style classification by using fund names. In particular, we take the list of 88 common index benchmarks from Cremers et al. (2016) and label as indexers all funds that refer in their names to one of these benchmarks.

[19] Following Gaspar et al. (2005), we use the variable "investor turnover," a measure of the investment horizon of institutions, to classify institutions as either long or short term. The rationale behind this measure is that an investor is classified as short term if it reshuffles its overall portfolio frequently. Alternatively, an investor is classified as long term if it holds its portfolio positions unchanged for a long time. Following Gaspar et al. (2013), we classify institutions with time averaged turnover rates in the bottom 33rd percentile as long-term investors.

[20] According to the data of Appendix C, Vanguard is the latest of the Big Three in increasing significantly its commitment to environmental issues. In terms of the values of the commitment index constructed based on these data, Vanguard is also the institution with the lowest values. These patterns provide a potential explanation for the results in Table 6. That said, we do find a negative and significant coefficient on *Vanguard_hldg* when we remove firm fixed effects from the specification (untabulated), suggesting that Vanguard also contributes (although perhaps to a lower degree) to the reduction of emissions.

Table 5
Changes in ownership

This table repeats the analysis in Table 4 using alternative specifications based on changes in ownership. Panel A replaces *Big3_hldg* with *Big3_increase*, defined as one if Δ_*Big3_hldg* > 1% and zero otherwise. *NonBig3_increase* is defined as one if Δ_*NonBig3_hldg* > 1% and zero otherwise. The sample spans from 2005 to 2018 and includes 19,224 firm-year observations in the MSCI subsample and 22,969 firm-year observations in the non-MSCI subsample. Panel B presents results for MSCI firms using a specification in changes. Δ_CO_2 ($t-s$, t) is the fractional change of CO_2 emissions from year $t-s$ to year t, that is, $(CO_{2t}-CO_{2t-s})/CO_{2t-s}$ (s = 1, ..., 12). Δ_*Big3_hldg* ($t-s-1$, $t-1$) is the change in *Big3_hldg* from year $t-s-1$ to year $t-1$. Δ_*NonBig3_hldg* ($t-s-1$, $t-1$) is the change in *NonBig3_hldg* from year $t-s-1$ to year $t-1$. Panel C repeats the analysis in Panel B for non-MSCI firms. The control variables are defined in Appendix A. Both subsamples span the period from 2005 to 2018. Independent variables are measured at the end of the prior year. Standard errors are clustered at the firm and year level in Panel A and at the firm level in Panels B and C. *t*-statistics are in parentheses. *, **, and *** denote significance at the 10%, 5%, and 1% levels (two-tail), respectively. Intercepts are omitted.

Panel A. Nonnegligible changes in Big Three ownership

	Dependent variable: Log(CO_2)					
	MSCI			Non-MSCI		
	(1)	(2)	(3)	(4)	(5)	(6)
Big3_increase	−0.10***	−0.04**	−0.02***	−0.05*	−0.02	0.00
	(−4.49)	(−2.52)	(−3.97)	(−1.65)	(−0.63)	(0.33)
NonBig3_increase	−0.02	−0.04*	−0.01*	−0.02	−0.03*	0.00
	(−0.65)	(−2.05)	(−1.93)	(−1.45)	(−2.09)	(0.50)
Controls	YES	YES	YES	YES	YES	YES
Country FE	YES	YES	NO	YES	YES	NO
Industry FE	YES	YES	NO	YES	YES	NO
Year FE	NO	YES	YES	NO	YES	YES
Firm FE	NO	NO	YES	NO	NO	YES
R^2	0.74	0.75	0.98	0.73	0.74	0.98
# obs.	19,224	19,224	19,134	22,969	22,969	22,468

Panel B. Specification in changes (MSCI firms)

	Dependent variable: Δ_CO_2 ($t-s$, t)											
	(1) $s=1$	(2) $s=2$	(3) $s=3$	(4) $s=4$	(5) $s=5$	(6) $s=6$	(7) $s=7$	(8) $s=8$	(9) $s=9$	(10) $s=10$	(11) $s=11$	(12) $s=12$
Δ_*Big3_hldg* ($t-s-1$, $t-1$)	−0.78**	−1.42*	−2.68**	−4.07**	−3.81*	−5.14**	−4.75**	−4.58**	−6.76*	−3.32*	−4.45**	−5.46*
	(−2.08)	(−1.82)	(−2.16)	(−2.18)	(−1.76)	(−2.11)	(−2.26)	(−2.52)	(−1.69)	(−1.90)	(−2.01)	(−1.88)
Δ_*NonBig3_hldg* ($t-s-1$, $t-1$)	0.20**	0.07	−0.34	−0.13	−0.65**	−1.48	−1.39*	−1.97*	−3.41	−1.31**	−0.97	−1.16
	(2.17)	(0.44)	(−0.73)	(−0.53)	(−2.02)	(−1.58)	(−1.83)	(−1.89)	(−1.53)	(−2.13)	(−1.20)	(−1.22)
Controls	YES	YES	YES	YES	YES	YES	YES	YES	YES	YES	YES	YES
Year FE	YES	YES	YES	YES	YES	YES	YES	YES	YES	YES	YES	YES
R^2	0.01	0.01	0.02	0.02	0.03	0.04	0.07	0.11	0.07	0.16	0.20	0.17
# obs.	16,980	14,917	13,025	11,350	9824	8,390	7,072	5,856	4,699	3,620	2,595	1,631

Panel C. Specification in changes (non-MSCI firms)

	Dependent variable: Δ_CO_2 ($t-s$, t)											
	(1) $s=1$	(2) $s=2$	(3) $s=3$	(4) $s=4$	(5) $s=5$	(6) $s=6$	(7) $s=7$	(8) $s=8$	(9) $s=9$	(10) $s=10$	(11) $s=11$	(12) $s=12$
Δ_*Big3_hldg* ($t-s-1$, $t-1$)	1.31	1.46	1.81	1.00	5.51	4.83	−1.23	−0.19	2.29	2.31	0.34	−2.34
	(1.20)	(0.87)	(1.06)	(0.90)	(1.04)	(1.06)	(−0.51)	(−0.06)	(0.63)	(0.53)	(0.10)	(−0.67)
Δ_*NonBig3_hldg* ($t-s-1$, $t-1$)	0.93*	1.51**	0.75	1.40	1.96	1.20	0.28	0.60	1.51	2.43	1.95	0.55
	(1.75)	(2.23)	(1.52)	(1.14)	(1.11)	(0.89)	(0.49)	(0.82)	(1.07)	(1.05)	(1.01)	(0.67)
Controls	YES	YES	YES	YES	YES	YES	YES	YES	YES	YES	YES	YES
Year FE	YES	YES	YES	YES	YES	YES	YES	YES	YES	YES	YES	YES
R^2	0.01	0.03	0.04	0.03	0.03	0.04	0.09	0.09	0.09	0.08	0.08	0.14
# obs.	16,964	11,765	7,638	6,237	4,982	3,953	3,306	2,714	2,162	1,613	1,165	717

one standard deviation increase in *Big3_hldg* in a given firm is associated with a reduction of approximately 2% in corporate CO_2 emissions (the within-firm standard deviation of *Big3_hldg* is 2.11%). Similarly, the magnitude of the coefficient on *Big3_increase* in Column (3) of Table 5 is close to −0.02, which also suggests a decrease of approximately 2% in corporate CO_2 emissions. A 2% decrease is a sizable effect when compared to current emission reduction goals proposed by environmental initiatives. For instance, the objective of the Regional Greenhouse Gas Initiative (RGGI) is to reduce emission cap by 2.5% each year from 2015 to 2020 (i.e., 12.5% in five years).[21] While among smaller, non-MSCI firms the potential effect of

[21] The RGGI founded in January 2007 is a state-level emissions capping and trading program carried out by nine northeastern US states (https://www.rggi.org/).

Table 6
Breakdown of ownership

This table repeats the analysis in Table 4 decomposing the variables *Big3_hldg* and *NonBig3_hldg*. The sample spans from 2005 to 2018 and includes 19,224 firm-year observations in the MSCI subsample and 22,969 firm-year observations in the non-MSCI subsample. *BlackRock_hldg* is BlackRock's holding in the firm, namely, the fraction of the firms' equity owned by BlackRock's mutual funds. *StateStreet_hldg* and *Vanguard_hldg* are defined in the same way for the other two Big Three institutions. *NonBig3_index* is fraction of the firm's equity held by indexers other than the Big Three. *NonBig3_nonindex* is the difference between *NonBig3_hldg* and *NonBig3_index*. *NonBig3_LT* is fraction of the firm's equity held by long-term investors other than the Big Three. *NonBig3_ST* is the difference between *NonBig3_hldg* and *NonBig3_LT*. *NonBig3_large* isthe fraction of the firm's equity held by large investors (top 100 by size) other than the Big Three. *NonBig3_small* is the difference between *NonBig3_hldg* and *NonBig3_large*. In columns (1)–(3) the rest of the specification is as in column (3) of Table 4. In columns (4)–(6) the rest of the specification is as in column (6) of Table 4. Standard errors are clustered at the firm and year level. *t*-statistics are in parentheses. *, **, and *** denote significance at the 10%, 5%, and 1% levels (two-tail), respectively. Intercepts are omitted.

	Dependent variable: Log (CO_2)							
	MSCI				Non-MSCI			
	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)
Big3_hldg		−0.82**	−1.10***	−0.96***		0.44	0.42	0.47
		(−2.33)	(−3.20)	(−2.79)		(1.47)	(1.49)	(1.63)
BlackRock_hldg	−2.79***				−0.21			
	(−5.27)				(−0.49)			
State Street_hldg	−2.45*				−0.84			
	(−1.94)				(−0.64)			
Vanguard_hldg	0.62				2.00***			
	(1.13)				(3.26)			
NonBig3_hldg	−0.05				0.18**			
	(−0.57)				(2.48)			
NonBig3_index		−1.49***				0.02		
		(−2.69)				(0.05)		
NonBig3_nonindex		−0.06				0.17**		
		(−0.60)				(2.42)		
NonBig3_LT			−0.34***				−0.03	
			(−2.56)				(−0.30)	
NonBig3_ST			0.14				0.28***	
			(1.39)				(4.05)	
NonBig3_large				−0.26**				0.15
				(−2.10)				(1.53)
NonBig3_small				0.12				0.20**
				(1.15)				(2.73)
Controls	YES	YES	YES	YES	YES	YES	YES	YES
Year FE	YES	YES	YES	YES	YES	YES	YES	YES
Firm FE	YES	YES	YES	YES	YES	YES	YES	YES
R^2	0.98	0.98	0.98	0.98	0.98	0.98	0.98	0.98
# obs.	19,134	19,134	19,134	19,134	22,468	22,468	22,468	22,468

the Big Three on corporate CO_2 emissions appears to be insignificant, MSCI firms account for a large portion of the market capitalization and a large part of the corporate CO_2 emissions. In our sample, the 16% of the firms included in the MSCI World Index account for 56% of the total CO_2 emissions (these data correspond to 2018, the most recent year in our sample period).

Nonetheless, some studies on climate change call for higher magnitudes to stop global warming; according to a recent study commissioned by the United Nations, the global volume of GHG emissions needs to drop by 55% by 2030 (i.e., around 5% each year) to limit global warming to 1.5°.[22] Moreover, an additional consideration is important for interpreting the magnitude of our results; the estimated effect based on our results (i.e., 2%) corresponds to the within-firm standard deviation of *Big3_hldg*, suggesting that we should not expect a 2% decrease in emissions across the board every year.

6. Sharpening identification

An obvious concern about our previous tests is that firms could reduce carbon emissions for reasons correlated with the ownership of the Big Three in the company. To the extent that our previous results are robust to controlling for time-invariant cross-sectional variation (our models include firm fixed effects), our inferences cannot be confounded by an omitted variable unless this variable covaries with our key variables not only in the cross-section but also in the time series. Nonetheless, we conduct several tests to sharpen identification.

6.1. Additional fixed effects

Table 7 presents the results of repeating the analysis in Tables 4 and 5 (Panel A) for the MSCI sample using a more restrictive fixed effect structure. In particular, we include country-by-year, industry-by-year, size-decile-by-year, and country-by-industry-by-year fixed effects. As shown in Table 7, our inferences are not sensitive to including these additional fixed effects; the coefficients on *Big3_hldg* and *Big3_increase* remain negative and significant across

[22] www.fastcompany.com/90272330/global-emissions-must-drop-55-by-2030-to-meet-climate-goals

Table 7
Additional fixed effects
This table repeats the analyses in Tables 4 and 5 (Panel A) for the MSCI sample including additional fixed effects. The sample spans from 2005 to 2018 and includes 19,224 firm-year observations in the MSCI subsample. The control variables are as in Table 4. Standard errors are clustered at the firm and year level. *t*-statistics are in parentheses. *, **, and *** denote significance at the 10%, 5%, and 1% levels (two-tail), respectively. Intercepts are omitted.

	Dependent variable: Log (CO_2)									
	Continuous variable					*Indicator for* Δ*_Big3_hldg* > 1%				
	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)	(9)	(10)
Big3_hldg	−1.21***	−1.24***	−0.87**	−0.98***	−0.53*					
	(−2.87)	(−3.78)	(−2.48)	(−2.77)	(−1.92)					
NonBig3_hldg	−0.03	0.06	−0.06	−0.08	0.06					
	(−0.21)	(0.77)	(−0.79)	(−0.81)	(0.87)					
Big3_increase						−0.05***	−0.02***	−0.02***	−0.02***	−0.01**
						(−5.65)	(−3.35)	(−4.06)	(−3.95)	(−2.12)
NonBig3_increase						−0.02**	0.00	−0.01*	−0.01**	−0.00
						(−2.16)	(0.09)	(−1.92)	(−2.41)	(−0.11)
Controls	NO	YES	YES	YES	YES	NO	YES	YES	YES	YES
Firm FE	YES	YES	YES	YES	YES	YES	YES	YES	YES	YES
Year FE	YES	NO	NO	NO	NO	YES	NO	NO	NO	NO
Country-year FE	NO	YES	NO	NO	NO	NO	YES	NO	NO	NO
Industry-year FE	NO	NO	YES	NO	NO	NO	NO	YES	NO	NO
Size-decile-year FE	NO	NO	NO	YES	NO	NO	NO	NO	YES	NO
Country-industry-year FE	NO	NO	NO	NO	YES	NO	NO	NO	NO	YES
R^2	0.97	0.98	0.98	0.98	0.99	0.97	0.98	0.98	0.98	0.99
# obs.	19,134	19,133	19,106	19,134	17,318	19,134	19,133	19,106	19,134	17,318

all models. Finally, Table 7 also includes a specification excluding the vector *Controls*. The results show that our inferences do not hinge on any of the control variables.

6.2. Cross-sectional variation in Big Three engagement

We next explore cross-sectional variation in the results in Table 4. If these results are related to Big Three influence, we expect the pattern in Table 4 to be more pronounced among firms with a higher probability of being the target of Big Three engagement. As such, this test links the analyses in Table 3 (i.e., the determinants of the probability that the Big Three engage with the firm) and Table 4 (i.e., the association between Big Three holdings and carbon emissions).

In particular, we repeat the analysis in Table 4 including the interaction between *Big3_hldg* and *Big3_target*, an indicator variable for firms with relatively higher probability of being the target of Big Three engagements. Specifically, *Big3_target* equals one if all three probabilities of engagement corresponding to each of the Big Three as predicted by the analysis in Table 3 are in the top quintile of the sample distribution and zero otherwise.[23] We use the probability of engagement by each institution rather than data on actual engagements because comparable engagement data are only available for all three institutions in the last year of our sample period. For completeness, we estimate two variants of this analysis redefining *Big3_target* as an indicator for whether all three estimated probabilities of engagements are in the top quartile and in the top tercile of the distribution, respectively.

As shown in Table 8, the interaction between *Big3_hldg* and *Big3_target* is negative and significant. The magnitude of the coefficient is larger when *Big3_target* is defined based on higher percentiles of the sample distribution. These results are consistent with the association between the Big Three and carbon emissions being more pronounced when these large funds engage with the firms' management on environmental issues. In Online Appendix OD.3 we repeat the analysis in Table 8 using an alternative measure of Big Three's engagement that does not rely on the specification in Table 3. Our inferences remain.

6.3. Time variation in Big Three engagement

We analyze whether the association between Big Three ownership and carbon emissions has evolved over time. Fig. 2 shows results of estimating Eq. (1) by year; we plot the coefficient on *Big3_hldg* estimated in annual cross-sectional regressions and the corresponding confidence intervals. The analysis reveals that the association between Big Three ownership and CO_2 emissions has increased substantially over time. In fact, the association appears to be significant only in the most recent years. This evidence is consistent with an increasing popular demand after the 2015 Paris Agreement that these large investors pressure the companies in their portfolios to curb their GHG emissions, as illustrated by recent public statements by climate activists and top executives of the Big Three.

We next explore whether this pattern is driven by a recent increase in the Big Three's commitment to deal with environmental issues. We measure the commitment of each of the three institutions to improve firms' environmental practices by constructing an index based on seven items corresponding to three categories: (i) engage-

[23] Specifically, we estimate the probability of engagement of BlackRock, State Street, and Vanguard using models (2), (5), and (8) in Table 3. We then code *Big3_target* for a given firm as one if the three estimated values are in the top quintile of the corresponding distributions of these three values for the sample firms.

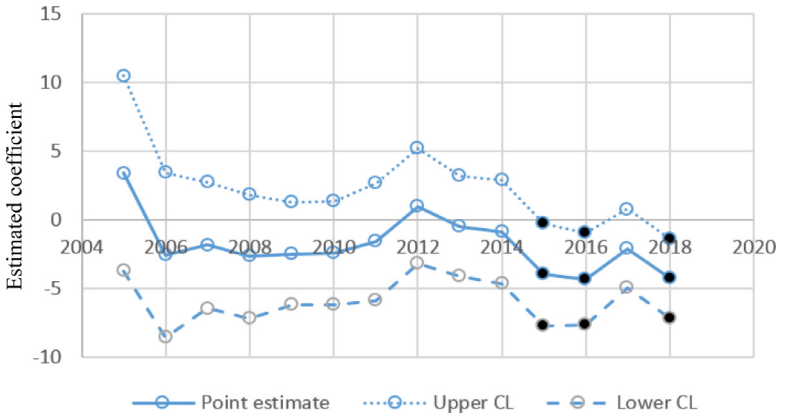

Fig. 2. Big Three ownership and carbon emissions by year. This figure reports the association between Big Three ownership and carbon emissions over time. The sample spans from 2005 to 2018 and includes 19,224 firm-year observations in the MSCI subsample. We estimate Eq. (1) year by year and plot the estimated coefficients on *Big3_hldg* (point estimates) in each year, along with the corresponding 95% confidence intervals. Filled dots (as opposed to empty dots) denote that the coefficient is statistically different from zero at the 10% level (two-tailed).

Table 8
Variation in the probability of Big Three engagement

This table presents an analysis of cross-sectional variation in the association between Big Three ownership and total carbon emissions based on the probability that the Big Three engages with the firm. The sample spans from 2005 to 2018 and includes 19,224 firm-year observations in the MSCI subsample. The dependent variable is the logarithm of CO_2 (i.e., the firm's total GHG emissions measured in equivalents of metric tons of CO_2). *Big3_hldg* is the fraction of the firm's equity owned by mutual funds sponsored by BlackRock, Vanguard, or State Street. *NonBig3_hldg* is the fraction of the firms' equity owned by funds managed by institutions other than BlackRock, Vanguard, and State Street. *Big3_target* equals one if all three probabilities of engagement by BlackRock, State Street, and Vanguard (as predicted by the analysis in Table 3) are in the top X percentile of the sample distribution and zero otherwise. In columns (1), (2), and (3) X percentile is, respectively, quintile, quartile, and tercile. The control variables are as in Table 4 (see Appendix A for definitions). The analysis is based on the MSCI firms covered by Trucost from 2005 to 2018. *Controls* is as in Table 4. See Appendix A for variable definitions. Independent variables are measured at the end of the prior year. Standard errors are clustered at the firm and year level. *t*-statistics are in parentheses. *, **, and *** denote significance at the 10%, 5%, and 1% levels (two-tail), respectively. Intercepts are omitted.

	Dependent variable: Log (CO_2)		
	Top quintile (1)	*Top quartile* (2)	*Top tercile* (3)
*Big3_hldg*Big3_target*	−1.80***	−0.93**	−0.77**
	(−3.29)	(−2.08)	(−2.22)
Big3_hldg	−0.81**	−0.93***	−1.05***
	(−2.30)	(−2.65)	(−2.83)
NonBig3_hldg	−0.09	−0.08	−0.08
	(−0.91)	(−0.80)	(−0.80)
Controls	YES	YES	YES
Year FE	YES	YES	YES
Firm FE	YES	YES	YES
R^2	0.98	0.98	0.98
# obs.	19,134	19,134	19,134

ment with the firms, (ii) voting behavior, and (iii) public statements. The data on each of these items is presented in Appendix C. We define the index in a straightforward way; we construct indicator variables based on the items in Appendix C and add up these indicator variables. For items 1, 4, and 6, we construct an indicator variable that equals one if the values are higher than a given threshold (see Appendix C for details). We label *BlackRock_commitment*, *StateStreet_commitment*, and *Vanguard_commitment* the corresponding indexes for BlackRock, State Street, and Vanguard, respectively. We then regress total CO_2 emissions on the interaction between the previous three variables with *BlackRock_target*, *StateStreet_target*, and *Vanguard_target*, defined as indicator variables for whether the probability of engagement (as predicted by the analysis in Table 3) for, respectively, BlackRock, State Street, and Vanguard is in the top quintile over the sample period. As shown in Table 9, Panel A, these interactions are negative and significant, which suggests that the increase in the Big Three's commitment to deal with environmental issues during recent years is associated with a decrease in CO_2 emissions.

As an alternative, corroborating analysis, we exploit the fact that *BlackRock_commitment*, *StateStreet_commitment*, and *Vanguard_commitment* increase substantially in specific years: 2017 for BlackRock, 2014 for State Street, and 2018 for Vanguard.[24] As shown in Appendix C (shadowed in gray), in these years the corresponding index increases by 50% and reaches a value equal or higher than 4. We

[24] There is anecdotal evidence associated with the data in Appendix C corroborating that these were years of change. For example, in 2017 BlackRock states for the first time that the environment is an engagement priority. In that same year, BlackRock's corporate governance and responsible investment team grows 50% (compared to only 10% over the period 2011-2016). Consistently, we observe that this institution engages with more firms on environmental issues starting in year 2017. That same year, BlackRock issues a significantly higher number of press releases covering environmental issues. Critically, early in 2017, Larry Fink made strong and unprecedented public statements on BlackRock's commitment to ESG issues (https://www.reuters.com/article/us-blackrock-climate-exclusive/exclusive-blackrock-vows-new-pressure-on-climate-board-diversity-idUSKBN16K0CR) and in May 2017 supported the ExxonMobil climate-related shareholder proposal. In sum, the data suggest that the year 2017 was a turning point in terms of BlackRock's efforts to induce firms to improve their environmental practices. Similarly, we observe that State Street's interest toward environmental issues increases significantly in 2014 (https://newsroom.statestreet.com/press-release/corporate/state-streets-corporate-responsibility-report-highlights-philanthropy-volunt) and that of Vanguard in 2018 (https://www.ft.com/content/5dbd7d56-1256-11e8-940e-08320fc2a277).

Table 9
Variation in Big Three's commitment to the environment

This table presents an analysis of time variation in the association between Big Three ownership and total carbon emissions based on the time-varying commitment of BlackRock, State Street, and Vanguard to tackle environmental issues. The dependent variable is the logarithm of CO_2 (i.e., the firm's total GHG emissions measured in equivalents of metric tons of CO_2). *BlackRock_target*, *StateStreet_target*, and *Vanguard_target* are, respectively, indicator variables for whether the probability of engagement by Blackrock, State Street, and Vanguard (as predicted by the analysis in Table 3) is in the top quintile of the distribution over the sample period. In Panel A, *BlackRock_commitment*, *StateStreet_commitment*, and *Vanguard_commitment* are, respectively, the time-varying commitment index of BlackRock, State Street, and Vanguard to tackle environmental issues (measured as described in Appendix C). . In Panel B, *Post_2016*, *Post_2013*, and *Post_2017* are indicator variables that equal one if the observation is after 2016, 2013, and 2017, respectively (as shown in Appendix C, these are the years of maximum increase in *BlackRock_commitment*, *StateStreet_commitment*, and *Vanguard_commitment*, respectively). In Panel A, the analysis is based on the 19,224 firm-year observations in the MSCI subsample from 2005 to 2018. In Panel B, the analysis is based on the MSCI subsample but restricted to a window of two years around 2016, 2013, and 2017 in columns (1), (2), and (3), respectively (in column (3) only one year is available post-2017). *Controls* is as in Table 4. See Appendix A for variable definitions. Independent variables are measured at the end of the prior year. Standard errors are clustered at the firm and year level. *t*-statistics are in parentheses. *, **, and *** denote significance at the 10%, 5%, and 1% levels (two-tail), respectively. Intercepts are omitted.

Panel A. Whole sample period

	Dependent variable: Log (CO_2)		
	(1)	(2)	(3)
*BlackRock_target***BlackRock_commitment*	−0.03***		
	(−5.20)		
*StateStreet_target***StateStreet_commitment*		−0.03***	
		(−3.90)	
*Vanguard_target***Vanguard_commitment*			−0.03***
			(−3.31)
Controls	YES	YES	YES
Year FE	YES	YES	YES
Firm FE	YES	YES	YES
R^2	0.98	0.98	0.98
# obs.	19,134	19,134	19,134

Panel B. Short-window analysis

	Dependent variable: Log (CO_2)		
	(1)	(2)	(3)
*BlackRock_target***Post_2016*	−0.04***		
	(−3.19)		
*StateStreet_target***Post_2013*		−0.03**	
		(−2.11)	
*Vanguard_target***Post_2017*			−0.03**
			(−2.28)
Controls	YES	YES	YES
Year FE	YES	YES	YES
Firm FE	YES	YES	YES
R^2	0.99	0.99	0.99
# obs.	5,212	5,405	3,870

then focus the analysis for each of the three institutions within the two-year window around the corresponding change and test whether CO_2 emissions decrease among the firms with higher probability of being targeted by that institution. As shown in Table 9, Panel B, the interactions between *BlackRock_target*, *StateStreet_target*, and *Vanguard_target* with the corresponding indicators for the years after the change (*Post_2017*, *Post_2014*, and *Post_2018*) are negative and significant. These results are also in line with the notion that the increase in the Big Three's commitment to deal with environmental issues is associated with a decrease in CO_2 emissions. In Online Appendix OD.4 we repeat the analysis in Table 9 using an alternative measure of the Big Three's commitment to deal with environmental issues and an alternative measure of the probability of the Big Three's engagement. Our inferences remain.

6.4. Plausibly exogenous variation in Big Three ownership

We further sharpen identification by exploiting the reconstitution of the Russell 1000/2000 indexes as a source of exogenous variation in Big Three ownership. Following prior literature (e.g., Appel et al., 2019a and others), we exploit the yearly reconstitution of the Russell 1000 and Russell 2000 indexes.[25] Every year, these indexes are formed based on end-of-May market capitalizations; the

[25] This approach has been widely used in the recent finance literature to assess the effect of passive investors on shareholder activism (Appel et al., 2019a), firms' corporate governance choices (Appel et al., 2016), payout policy (Crane et al., 2016), CEO power and composition of board of directors (Schmidt and Fahlenbrach, 2017), and firm transparency and information production (Boone and White, 2015).

largest 1000 companies constitute the Russell 1000 (i.e., firms #1–1000), while the next 2000 firms in size are included in the Russell 2000 Index (i.e., firms #1001–3000). For companies that are around the 1000/2000 cutoff, the final assignation to the index is relatively random in the sense that it can be determined by random variations in market value. Because the firm-specific weight in the index is value weighted (as a function of float-adjusted market capitalization as of the end of June), the position at the top of the Russell 2000 Index rather than at the bottom of the Russell 1000 Index results in a significant increase in the company's weight in the index, which triggers stock purchases by index funds tracking the indexes.

Therefore, for each dollar invested in a passive fund using the Russell 1000 as a benchmark, very little of that dollar will be invested in stocks at the bottom of that index; while for each dollar invested in a passive fund using the Russell 2000 as a benchmark, a large proportion of that dollar will be invested in stocks at the top of the index. To the extent that the Big Three invest heavily in funds tracking the Russell indexes, the shift from Russell 1000 to Russell 2000 likely increases Big Three ownership in the firm.[26]

Our specification follows the recommendations of recent methodological papers studying the use of the Russell index assignment as a source of exogenous variation in firms' ownership structures (Appel et al., 2019b; Glossner, 2018; Wei and Young, 2019; Ben-David et al., 2019). Following Appel et al. (2019a), we conduct a 2SLS (two-stage least squares) IV (instrumental variable) estimation including the bottom 500 stocks of the Russell 1000 and top 500 stocks of the Russell 2000.[27]

$$\begin{aligned}\text{First stage: } Big3\_hldg_{it} &= \alpha + \beta^{*}Russell2000_{it} + \Sigma\lambda_n{}^{*}(\ln(Mktcap_{it}))^{n} \\ &+ \nu^{*}\ln(Float_{it}) + \phi_1{}^{*}Band_{it} + \phi_2{}^{*}Russell2000_{it\text{-}1} \\ &+ \phi_3{}^{*}Band_{it}{}^{*}Russell2000_{it\text{-}1} + \tau_t + \delta_i + \varepsilon_{i,} \qquad (2)\end{aligned}$$

$$\begin{aligned}\text{Second stage : } Log(CO_2)_{it+1} &= \alpha + \beta * \widehat{Big3\_hldg_{it}} + \sum \lambda_n * (\ln(Mktcap_{it}))^{n} \\ &+ \nu * \ln(Float_{it}) + \phi_1 * Band_{it} + \phi_2 * Russell2000_{it-1} \\ &+ \phi_3 * Band_{it} * Russell2000_{it-1} + \tau_t + \delta_i + \varepsilon i. \qquad (3)\end{aligned}$$

$Russell2000_{it}$, the IV, is defined as an indicator equal to one if stock i is assigned to the Russell 2000 Index in year t. $Mktcap_{it}$ is the market capitalization of stock i as of the end of May of year t computed following Ben-David, Franzoni, and Moussawi's (2019) methodology to approximate the ranking variable used by Russell to assign stocks to indexes.[28] $Float_{it}$ is the float-adjusted market capitalization of stock i as of the end of June of year t used by Russell to determine firm-specific index weights (Russell resorts stocks within indexes using float-adjusted market capitalization measured at the end of June). $Band_{it}$ equals one if the firm's end-of-May market capitalization is within the banding interval and zero otherwise (see Online Appendix OC for more details on Russell's index assignment procedure). $Russell2000_{it\text{-}1}$ equals one if the firm is in Russell 2000 in the previous reconstitution year and zero otherwise. Finally, the specification also includes firm and year fixed effects. We repeat the analysis using three alternative bandwidths; we estimate Eqs. (2) and (3) including the 500, 400, and 300 bottom/top stocks of the Russell 1000/2000. To account for the possibility that the effect of being included in the index on *Big3_hldg* is not linear, we include polynomial controls with degree (N) 1, 2, and 3 for the firms' market capitalization.[29]

Table 10, Panel A reports results of the first-stage estimations. *Russell2000* loads with positive and highly significant coefficients in all specifications, suggesting that the aggregate ownership by the Big Three is almost one percentage point higher for firms in the top of Russell 2000 Index than for the other firms around the cutoff.[30] Table 10, Panel B reports the results of the second-stage estimation. The coefficient on *Big Three* is generally negative and significant. Compared to the average of the estimated coefficients in Table 4, the magnitude of the coefficient on Big Three ownership in Table 10 is larger. The estimated coefficient on $\widehat{Big3\_hldg_{it}}$ (which ranges

[26] Appel et al. (2019a) show that ownership by passively managed mutual funds and ETFs is about 40% higher, on average, for stocks at the top of the Russell 2000 Index relative to otherwise similar stocks at the bottom of the Russell 1000 Index. Additionally, (Appel et al., 2016) report that, on average, the ownership stakes of the three biggest passive investors are a third higher among firms at the top of the Russell 2000, and each of these three institutions' likelihood of owning more than 5% of a firm's shares increases by two-thirds, on average, while their likelihood of being a top five shareholder is higher, on average, by 15%.

[27] Prior literature also uses a regression discontinuity (RD) approach around the Russell 1000/2000 reconstitution. Appel et al. (2019b) point out two important limitations of the RD approach. First, it is not possible to use the sharp RD approach for sample years after 2006 (focusing on the pre-2006 period would limit the power of our test, as our sample starts in 2005). Second, the RD approach does not provide a direct way to quantify the effect of firms' ownership structure on firm outcomes because the first stage of the fuzzy RD approach does not include a measure of institutional ownership. To overcome these difficulties, Appel et al. (2019b) recommend an alternative approach, namely the 2SLS IV. We follow their recommendation.

[28] A common theme in the papers discussing the validity of the Russell 1000/2000 reconstitution as identification strategy is that the end-of-May market capitalization ranking used by Russell to determine firms' index assignment at reconstitution is not observable to the econometrician (Appel et al., 2019b; Glossner, 2018; Wei and Young, 2019; Ben-David et al., 2019). As such, the literature uses a variety of approaches to approximate this ranking, notably computing end-of-May market capitalization based on CRSP. In a recent paper, Ben-David et al. (2019) develop a procedure that predicts assignment to the Russell 1000/2000 with significant improvements relative to previous approaches.

[29] We repeat the analysis replacing *Big3_hldg* with *NonBig3_hldg*. To the extent that index investing is more prevalent among the Big Three than among other investment companies, this additional analysis is a placebo test. As shown in Online Appendix OD, Section OD.5, in this placebo test we do not find significant results in either of the two stages of the estimation.

[30] The strong association between *Big3_hldg* and *Russell2000* suggests that the "relevance condition" of the IV approach is satisfied. The value of the Kleibergen-Paap F-statistic is greater than 12, which further alleviates the concern that the instrument is "weak" (uncorrelated with the endogenous regressor).

Table 10
Exploiting the reconstitution of the Russell 1000/2000

This table presents an instrumental variable (IV) 2SLS analysis of the association between firm carbon emissions and Big Three ownership. The analysis exploits the reconstitution of the Russell 1000/2000 indexes. The results correspond to the estimation of the following model (Appel et al., 2019a):

$$\text{First stage (Panel A): } Big3\_hldg_{it} = \alpha + \beta^{*}Russell2000_{it} + \Sigma\lambda_n{}^{*}(\ln(Mktcap_{it}))^n + \nu^{*}\ln(Float_{it}) + \phi_1{}^{*}Band_{it} + \phi_2{}^{*}Russell2000_{it\text{-}1} + \phi_3{}^{*}Band_{it}{}^{*}Russell2000_{it\text{-}1} + \tau_t + \delta_i + \varepsilon_{it}, \quad (1)$$

$$\text{Second stage (Panel B): Log } (CO_2)_{it+1} = \alpha + \beta^{*}\widehat{Big3\_hldg}_{it} + \Sigma\lambda_n{}^{*}(\ln(Mktcap_{it}))^n + \nu^{*}\ln(Float_{it}) + \phi_1{}^{*}Band_{it} + \phi_2{}^{*}Russell2000_{it\text{-}1} + \phi_3{}^{*}Band_{it}{}^{*}Russell2000_{it\text{-}1} + \tau_t + \delta_i + \varepsilon_{it}. \quad (2)$$

Big3_hldg is the fraction of the firms' equity owned by mutual funds sponsored by BlackRock, Vanguard, or State Street. $Russell2000_{it}$, the instrument, equals one if stock *i* is assigned to the Russell 2000 Index in year *t*, and zero otherwise; $Mktcap_{it}$ is the market capitalization of stock *i* as of the end of May of year *t* following Ben-David et al. (2019)'s methodology; $Float_{it}$ is the float-adjusted market capitalization of stock *i* as of the end of June of year *t* used by Russell to determine firm-specific index weights. Log (CO_2) is the logarithm of the firm's total GHG emissions per year measured in equivalents of metric tons of CO_2. $Band_{it}$ equals one if the firm's end-of-May market capitalization is within the banding interval (see Online Appendix C) and zero otherwise; $Russell2000_{it\text{-}1}$ equals one if the firm was in the Russell 2000 Index in the previous year and zero otherwise. $\widehat{Big3\_hldg}_{it}$ is the fitted value of *Big3_hldg* from the first-stage estimation. The model includes polynomial controls of order 1, 2, and 3. The samples in columns (1), (2), and (3) include 5643, 4371, and 3182 firm-year observations within bandwidths of 500, 400, and 300 (respectively) around the threshold between Russell 1000 and Russell 2000 in the years 2005–2018 (the same applies to the other two sets of columns). Panel A and B present results of the first and second stage, respectively. Standard errors are clustered at the firm and year level. *t*-statistics are reported in parentheses. *, **, and *** indicate statistical significance at the 10%, 5%, and 1% levels, respectively. Intercepts are omitted.

Panel A. First stage

	Dependent variable: $Big3\_hldg_t$								
	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)	(9)
$Russell2000_t$	0.01***	0.01***	0.01***	0.01***	0.01***	0.01***	0.01***	0.01***	0.01***
	(4.87)	(5.57)	(5.79)	(4.80)	(5.43)	(5.80)	(4.40)	(5.35)	(5.75)
Polynomial order, N	1	1	1	2	2	2	3	3	3
Bandwidth	500	400	300	500	400	300	500	400	300
Float control	YES	YES	YES	YES	YES	YES	YES	YES	YES
Firm FE	YES	YES	YES	YES	YES	YES	YES	YES	YES
Year FE	YES	YES	YES	YES	YES	YES	YES	YES	YES
Kleibergen-Paap F-stat.	23.71	31.08	33.58	23.02	29.46	33.61	19.39	28.57	33.11
R^2	0.91	0.91	0.91	0.91	0.91	0.91	0.91	0.91	0.91
# obs.	5,643	4,371	3,182	5,643	4,371	3,182	5,643	4,371	3,182

Panel B. Second stage

	Dependent variable: Log $(CO_2)_{t+1}$								
	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)	(9)
$\widehat{Big3\_hldg}_t$	−6.65*	−6.86**	−5.34*	−6.61*	−6.85**	−5.34*	−6.39	−6.66**	−5.34*
	(−1.68)	(−2.12)	(−1.80)	(−1.70)	(−2.06)	(−1.80)	(−1.63)	(−2.03)	(−1.83)
Polynomial order, N	1	1	1	2	2	2	3	3	3
Banding controls	YES	YES	YES	YES	YES	YES	YES	YES	YES
Bandwidth	500	400	300	500	400	300	500	400	300
Float control	YES	YES	YES	YES	YES	YES	YES	YES	YES
Firm FE	YES	YES	YES	YES	YES	YES	YES	YES	YES
Year FE	YES	YES	YES	YES	YES	YES	YES	YES	YES
R^2	0.98	0.98	0.98	0.98	0.98	0.98	0.98	0.98	0.98
# obs.	5,643	4,371	3,182	5,643	4,371	3,182	5,643	4,371	3,182

from −5.34 to −6.86) suggests that a one percentage point increase in Big Three ownership (which is close to its within-firm standard deviation) is associated with a reduction of CO_2 emissions of around 7%.[31]

7. Conclusion

This paper examines the role of the Big Three (i.e., BlackRock, Vanguard, and State Street Global Advisors) on the reduction of corporate carbon emissions around the world. Using novel data on engagements of the Big Three with individual firms, we find evidence that these

[31] Given the local nature of the Russell 1000/2000 experiment, we warn about generalizing the magnitudes of this test to the full sample. The fact that the magnitude of the coefficient on $\widehat{Big3\_hldg}_{it}$ is larger than that in Table 4 is consistent with the results of similar tests in prior literature (e.g., Ben David et al., 2018). The difference can be due to several reasons. First, Big Three ownership is higher among US firms than among non-US firms (the average Big Three ownership in the firms included in the Russell 1000/2000 test is 12%). Second, the firms included in the Russell 1000/2000 test are not the largest ones (the largest firms are far away from the switching threshold). This could result in a more pronounced reduction in CO_2 emissions to the extent that the Big Three are more influential among smaller firms (smaller firms cannot afford upsetting large investors because these firms have more limited financing opportunities). Third, admittedly the difference in the magnitude of the coefficients between Tables 4 and 10 could be partly driven by estimation error; a negative omitted variable bias in the OLS estimation or distortions in the second-stage estimation induced by inaccuracies in the first stage.

engagements are related to CO_2 emissions and that the Big Three focus their engagement efforts on large firms in which they hold a significant stake. We also find that higher ownership by the Big Three is followed by lower carbon emissions. This pattern is stronger when the firm is more likely to be the target of Big Three engagements and especially so in later years of the sample period as the Big Three increase their commitment to deal with environmental issues.

Overall, our results are consistent with the notion that firms under the influence of the Big Three are more likely to reduce corporate carbon emissions. Our evidence is particularly relevant considering that large investment institutions are increasingly viewed as catalysts in driving firms to reduce their carbon emissions (Andersson et al., 2016; OECD, 2017).

The interpretation of our results is subject to at least three caveats. First, while suggestive, our evidence is not enough to demonstrate a causal effect of Big Three influence on corporate CO_2 emissions. Further research is needed to establish such a causal link. Second, our results do not speak to whether the reduction in CO_2 emissions associated with Big Three ownership increases shareholder wealth. Third, our tests do not necessarily imply that the level of monitoring provided by the Big Three is (net) socially optimal. We look forward to future research shedding further light on these important issues.

Appendix A. Variable definitions

Log(CO_2)	Logarithm of the total GHG emissions of the firm measured in equivalents of metric tons of CO_2.
Size	Logarithm of the firm's total assets.
Log(BM)	Logarithm of the book value of common equity scaled by the market value of equity.
ROA	Net income scaled by total assets.
Leverage	Total debt scaled by total assets. Total debt is the sum of long-term debt and the debt in current liabilities.
PPE	Property, plant, and equipment (PPE) scaled by total assets.
Engagement_BlackRock	Indicator variable that equals one if BlackRock engages with the firm from July 1, 2018 until June 30, 2019 and zero otherwise. The data include all engagements.
Engagement_StateStreet	Indicator variable that equals one if State Street Global Advisors engages with the firm from January 1, 2018 until December 31, 2018 and zero otherwise. The data include engagements about Environmental/Social issues.
Engagement_Vanguard	Indicator variable that equals one if Vanguard engages with the firm from July 1, 2018 until December 31, 2018 and zero otherwise. The data include engagements about "oversight of strategy and risk" (which include environmental issues).
Big3_hldg	Big Three's holding in the firm, namely, the fraction of the firms' equity owned by mutual funds managed by BlackRock, Vanguard, or State Street Global Advisors.
BlackRock_hldg	BlackRock's holding in the firm, namely, the fraction of the firms' equity owned by BlackRock's mutual funds.
StateStreet_hldg	State Street's holding in the firm, namely, the fraction of the firms' equity owned by State Street Global Advisors's mutual funds.
Vanguard_hldg	Vanguard's holding in the firm, namely, the fraction of the firms' equity owned by Vanguard's mutual funds.
MSCI_constituent	Indicator variable that equals one if the firm is an MSCI constituent and zero otherwise.
NonBig3_hldg	Non-Big Three's holding in the firm, namely, the fraction of the firms' equity owned by funds managed by institutions other than BlackRock, Vanguard, and State Street Global Advisors.
NonBig3_index	Fraction of the firm's equity held by indexers other than the Big Three.
NonBig3_nonIndex	Difference between *NonBig3_hldg* and *NonBig3_index*.
NonBig3_LT	Fraction of the firm's equity held by long-term investors other than the Big Three. An investor is defined as a long term if its portfolio turnover is in the bottom 33rd percentile of the distribution.
NonBig3_ST	Difference between *NonBig3_hldg* and *NonBig3_LT*.
NonBig3_large	Fraction of the firm's equity held by the largest 100 institutions by assets under management (AUM) other than the Big Three.
NonBig3_small	Difference between *NonBig3_hldg* and *NonBig3_large*.
Big3_target	Indicator variable that equals one if all three probabilities of engagement by BlackRock, State Street and Vanguard (as predicted by the analysis in Table 3) are in the top quintile of the sample distribution and zero otherwise.
BlackRock_target	Indicator variable for whether the probability of engagement by BlackRock (as predicted by the analysis in Table 3) is in the top quintile of the distribution over the sample period.
StateStreet_target	Indicator variable for whether the probability of engagement by State Street Global Advisors (as predicted by the analysis in Table 3) is in the top quintile of the distribution over the sample period.
Vanguard_target	Indicator variable for whether the probability of engagement by Vanguard (as predicted by the analysis in Table 3) is in the top quintile of the distribution over the sample period.
BlackRock_commitment	Time-varying index measuring BlackRock's commitment to deal with environmental issues (see Appendix C for details).
StateStreet_commitment	Time-varying index measuring State Street Global Advisors' commitment to deal with environmental issues (see Appendix C for details).
Vanguard_commitment	Time-varying index measuring Vanguard's commitment to deal with environmental issues (see Appendix C for details).

Appendix B. Data on corporate carbon emissions

B.1. Process followed by Trucost to assess corporate carbon emissions

Trucost has developed a comprehensive approach to evaluate corporate carbon emissions. This approach employs an environmental profiling model that tracks 464 industries worldwide. In particular, Trucost follows four steps (Ung et al., 2016):

1. Analysis of company data: Financial information is assessed to establish the primary business activities of an organization. Revenues to those activities are apportioned accordingly.
2. Mapping of company data: Using the information in step 1, the environmental profiling model calculates an organization's direct and supply chain environmental impacts.
3. Incorporation of disclosures and public data: The analysis incorporates reported environmental data obtained from public sources (such as annual reports and websites). Where environmental reporting is not available, Trucost draws on sources of proxy information (namely, fuel use, or expenditure data), which can be converted into emissions data. Reported figures are standardized for consistency.
4. Company verification process: Each analyzed company is invited to verify or refine the environmental assessment conducted by Trucost.

B.2. Example of corporate carbon emissions

The table below reproduces the GHG emission amounts reported by 3 M Co. to the Carbon Disclosure Project (CDP). Amounts are expressed in tons and in CO_2 equivalents to aid comparison.

Emission	Source	Quantity Tonnes	CO2 Equivalent (CO2e) Tonnes
Direct CO2e (Scope1)			3,288,540
Carbon Dioxide To Air	CDP	3,191,764	3,191,764
HFCs To Air	CDP	14	34,045
Dinitrogen Oxide (Nitrous Oxide) To Air	CDP	108	33,586
PFCs To Air	CDP	2.69	21,094
methane to air	cdp	248	5,201
sulphur hexafluoride to air	cdp	0.12	2,849
Other Direct CO2e			4,892
Other Direct CO2e	PRE	–	4,892
First Tier Supply Chain (Scope 3) CO2e			3,977,000
Purchased Electricity (Scope 2) CO2e	CDP	–	1,690,000
Non-Electricity Supply Chain (Scope 3) CO2e	TC	–	2,287,000
All Other Supply Chain (Scope 3) CO2e			4,072,000
Sum Of All Other Supply Chain (Scope 3) CO2e	TC	–	4,072,000
Total			11,342,431

Appendix C. Measurement of Big Three's attention to environmental issues

Panel A. BlackRock

	Indicator var.	2011	2012	2013	2014	2015	2016	2017	2018
Engagement									
# meetings related to E	1 if > 100, 0 otw.	0	0	1	0	0	0	1	1
E is an engagement priority		0	0	0	0	0	0	1	1
Voting									
Proxy voting guidelines include E		0	0	0	0	1	1	1	1
# votes for E proposals	1 if > 10%, 0 otw.	0	0	0	0	0	0	0	0
Public statements									
CEO letter cites E		0	1	0	0	0	1	1	1
# press releases about E	1 if > 10, 0 otw.	1	0	0	0	0	0	1	1
PRI signatory		1	1	1	1	1	1	1	1

Panel B. State Street

	Indicator var.	2011	2012	2013	2014	2015	2016	2017	2018
Engagement									
# meetings related to E	1 if > 100, 0 otw.	0	0	0	0	0	0	1	0
E is an engagement priority		1	1	1	1	1	1	1	1
Voting									
Proxy voting guidelines include E		0	0	0	1	1	1	1	1
# votes for E proposals	1 if > 10%, 0 otw.	0	0	0	1	1	1	1	1
Public statements									
CEO letter cites E		0	0	0	0	0	0	1	0
# press releases about E	1 if > 10, 0 otw.	0	0	0	0	0	0	1	0
PRI signatory		0	1	1	1	1	1	1	1

Panel C. Vanguard

	Indicator var.	2011	2012	2013	2014	2015	2016	2017	2018
Engagement									
# meetings related to E	1 if > 100, 0 otw.	0	0	0	0	0	0	0	1
E is an engagement priority		0	0	0	0	0	0	0	0
Voting									
Proxy voting guidelines include E		0	0	0	0	0	0	0	0
# votes for E proposals	1 if > 10%, 0 otw.	0	0	0	0	0	0	0	1
Public statements									
CEO letter cites E		0	0	0	0	0	0	0	1
# press releases about E	1 if > 10, 0 otw.	0	0	0	0	0	0	1	0
PRI signatory		0	0	0	0	1	1	1	1

Panel D. Index of commitment to deal with environmental engagement (sum of above seven indicator variables)

	2011	2012	2013	2014	2015	2016	2017	2018
BlackRock	2	2	2	1	2	3	6	6
State Street Global Advisors	1	2	2	4	4	4	7	4
Vanguard	0	0	0	0	1	1	2	4

Notes: "E" stands for "the environment" (which includes climate-related issues and carbon emissions).

(i) "PRI" stands for principles for responsible investment.

All data items and the index values are zero before 2011. We manually gather above information from public records of CEO letters, investment stewardship annual reports, proxy voting and engagement guidelines, and a Factiva search on the press releases about the Big Three investors on the main US and UK newspapers using the following keywords: "proxy voting guidelines," "environmental shareholders proposals," "climate risk/change," "CEO letter."

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