Energy Economics 115 (2022) 106376

Contents lists available at ScienceDirect

Energy Economics

journal homepage: www.elsevier.com/locate/eneeco

Do all institutional investors care about corporate carbon emissions?

Md Safiullah [a], Md Samsul Alam [b], Md Shahidul Islam [c,*]

[a] *RMIT University, School of Economics, Finance and Marketing, Melbourne, Australia*
[b] *Sheffield University Management School, The University of Sheffield, Sheffield, UK*
[c] *Essex Business School, University of Essex, UK*

ARTICLE INFO

JEL classification:
G23
G32
G34
M14

Keywords:
Carbon emissions
Institutional investors
Monitoring
Investment horizons

ABSTRACT

This paper investigates whether institutional investors promote the abatement of corporate carbon emissions. Using firm-level data on the U. S from 2007 to 2017, we find that institutional investors help reduce carbon emissions. The result is more pronounced in firms with more independent (investment companies, investment advisors, and pension funds), long-term, and monitoring institutional ownership. Our result holds when we employ a quasi-natural experiment and the difference-in-differences approach to address endogeneity. The channel analysis documents that institutional investors help reduce carbon emissions by reducing energy consumption. We also find that shareholder activism is a proximal monitoring mechanism through which institutional investors influence firms to achieve better carbon performance. Finally, our results show that the advantage for institutional investors from reducing carbon emissions is higher firm value.

"If we don't embrace a low carbon economy this decade, it won't just harm the planet, but also the U.S. economy."
—John Doerr, an influential American investor and venture capitalist.

"Climate change and the policies created to address it have significant implications for businesses – it will fundamentally change many products, services, and operating models. Successful companies need to measure and manage those risks and actively seek the opportunities a clean economy creates. We need to invest for the future not the past."
— Ignacio S. Galán, Chairman and Chief Executive Officer, Iberdrola.

1. Introduction

This study examines the effect of institutional investors on carbon emissions in U.S. firms. We focus on whether all institutional investors equally treat carbon emissions. To perform this analysis, apart from the aggregate measure of total institutional ownership, we employ measures of ownership by independent and grey institutional investors (Chen et al., 2007); long-term and short-term institutional investors (Gaspar et al., 2005); and monitoring institutional investors (Fich et al., 2015). Institutional investors are diverse regarding their focus, objectives, behaviour, and incentives (Bushee, 1998; Chen et al., 2007). Our empirical setting enables us to capture such variation among institutional investors and its implications for carbon emissions.

Carbon emissions have been receiving attention from regulators, policymakers, investors, firms, and wider stakeholders of society, as its rise escalates climate change and endangers the world's ecological system. To minimize carbon emissions and their negative consequences, various environmental treaties and agreements have been undertaken on the local, regional, and international levels. For instance, the Paris Climate Agreement (COP21), adopted in 2015, encouraged its 195 signatory countries to undertake effective policies and initiatives to curb the rise of the world temperature by 2 °C. These treaties and agreements have put pressure on business enterprises to improve their environmental performance. Consequently, the environmental impact of business activities has come under augmented scrutiny by various stakeholders of business, including investors and customers (Hart, 1995; Hopwood, 2009). In recent research, U.S. Trust (2018) finds that three out of four influential investors consider the environmental and social influence of business activities before they make investment decisions. Nielsen (2014) suggests that 66% of consumers in 60 countries worldwide are keen to pay higher prices for environmentally friendly products and services. In response to the augmented interest of various stakeholders in firms' environmental strategy, large corporations are considering the environmental consequences of their actions and setting

* Corresponding author.
E-mail addresses: md.safiullah@rmit.edu.au (M. Safiullah), m.alam@sheffield.ac.uk (M.S. Alam), m.s.islam@essex.ac.uk (M.S. Islam).

https://doi.org/10.1016/j.eneco.2022.106376
Received 15 August 2021; Received in revised form 24 July 2022; Accepted 11 October 2022
Available online 21 October 2022

specific targets for carbon emissions abatement (Chatterji et al., 2009; Liesen et al., 2017).[1] To this end, our study attempts to answer an open research question: do institutional investors promote abatement of firm-level carbon emissions?

From a theoretical point of view, institutional investors, given their large stockholding, may promote the abatement of carbon emissions to secure the insurance-like benefit of such environmental responsibility (Shiu and Yang, 2017). Involvement in environmentally responsible activities develops a trustworthy relationship between firms and their major stakeholders, which pays off when firms experience an adverse shock in a crisis (Minor and Morgan, 2011; Lins et al., 2017). Institutional investors are likely to play a proactive role in initiatives for carbon emissions reduction to minimize the possible financial losses emanating from the reduction of reputational image and competitive advantage due to high carbon emissions (Labatt and White, 2011; Aghion et al., 2013).

However, according to the "passive monitoring" view, institutional investors are considered short-term traders that are interested in speculative short-term trading profits based on information advantages (Kochhar and David, 1996) to satisfy their portfolio needs (Elyasiani and Jia, 2010) rather than concentrating on reducing carbon emissions for long-term profit. Therefore, no relationship or a weak relationship should be expected between firm carbon performance and institutional ownership.

The contribution of our study to the literature on institutional investors is fourfold. First, unlike our predecessors (Starks et al., 2017; Dyck et al., 2019; Fu et al., 2019; Gloßner, 2019; Kim et al., 2019a), we examine the role of institutional investors in promoting carbon emissions reduction. We pay special attention to carbon emissions because carbon emissions are considered a critical environmental issue contributing to climate change across the globe. Additionally, the concept of corporate responsibility is very broad, and the use of composite corporate social responsibility measures (e.g., the ESG index) may mask the role of institutional investors in carbon emissions abatement. Further, unlike carbon emissions, corporate social responsibility measures are not a direct and auditable measure of environmental performance measure (Bose et al., 2021).

Second, prior studies have used the measure of total institutional ownership (Dyck et al., 2019), long-term and short-term institutional ownership (Gloßner, 2019; Kim et al., 2019a), and domestic and distant institutional ownership (Kim et al., 2019b) to examine the effect of institutional ownership on corporate performance. Although their studies are important, given that each focus on a single set of institutions, the extent to which their findings generalize is unclear. Differing from our predecessors, we use carbon emissions and measures of total institutional ownership, independent and grey institutional ownership (Chen et al., 2007); long-term and short-term institutional ownership (Gaspar et al., 2005); and monitoring institutional ownership as proposed by Fich et al. (2015). Our study, therefore, provides a comprehensive examination of institutional investors and carbon emissions, which is essential in providing a more comprehensive view of institutional investors' influence on carbon emissions abatement. Institutional investors vary in terms of their focus, objectives, behaviour, and incentives (Bushee, 1998; Chen et al., 2007), and examining the effect of a certain group of institutional investors on carbon emissions provides incomplete evidence. Such a rigorous study on institutional investors and carbon emissions has not hitherto been undertaken. Our study fills this vital gap.

Third, we explore channels through which institutional investors may contribute to reducing carbon emissions. To do so, initially, we examine whether institutional investors focus on energy consumption as a mechanism to influence firms' carbon emissions. Energy consumption is a plausible channel because the carbon emissions level is attributable to the level of energy consumption by firms. Further, we use carbon emissions-related shareholder proposals or voices as a more proximal monitoring channel through which institutional investors can influence a firm's decisions and policies on carbon emissions. Hence, our study adds to the stream of extant literature (Neubaum and Zahra, 2006; Chen et al., 2020) that shows shareholder activism is an important mechanism through which institutional investors push firms to achieve better performance, including CSR activities. Finally, our study extends the value relevance literature (Chapple et al., 2013; Clarkson et al., 2015; Matsumura et al., 2014; Griffin et al., 2017) by examining that, for a given level of emissions, investors value firms differently that have a higher presence of institutional investors.

Using a sample of 12,976 firm-year observations from 2106 U.S firms during the period 2007–2017, we find that firms with higher institutional ownership experience fewer carbon emissions. This result holds true, particularly in firms with more independent (investment companies, investment advisors, and pension funds), long-term, and monitoring institutional ownership. Our results indicate that institutional investors do contribute to abating carbon emissions by reducing energy consumption. We also show that shareholder proposals serve as a monitoring mechanism to reduce carbon emissions. Our study further reveals that the benefit for institutional investors from reducing carbon emissions is higher firm value. These results are robust across alternative econometric specifications and hold true to the use of various control variables.

We address potential endogeneity concerns using three different approaches. Firstly, we use firm fixed effects and lagged independent variables. Secondly, we employ the BP Deepwater Horizon oil spill as a quasi-natural experiment to investigate whether institutional investors cause the reduction of carbon emissions. Finally, we use the mandatory cap-and-trade program employed by the Regional Greenhouse Gas Initiative (RGGI), which is an initiative of nine U.S. states for carbon emissions abatement. For our estimation purposes, we employ the significant changes in RGGI's initiatives in 2012 in difference-in-difference estimations to address the concern of causality. The negative effect of independent, long-term, and monitoring institutional investors on carbon emissions remains when we employ these shocks to address endogeneity concerns.

The remainder of the paper is structured as follows: Section 2 highlights the development of research questions and theoretical perspectives. Section 3 provides a data and sample description. Section 4 presents the empirical results. Section 5 addresses endogeneity issues, while Section 6 presents additional tests. Section 7 reports on the channel analysis. Section 8 presents the value relevance of the effect of institutional investors on carbon emissions, followed by the conclusion in Section 9.

2. Development of the research questions and theoretical perspectives

We start this section by assessing the extant literature that investigates the impact of institutional ownership on corporate policies to identify research gaps and finalize research questions. We then focus on theoretical arguments for why institutional investors are more likely to make environment-friendly decisions to curb carbon emissions.

2.1. Development of the research questions

A large volume of studies investigates the impact of institutional investors on firm performance and corporate policies. Empirical studies show that institutional investors have positive (Smith, 1996; Yuan et al., 2008; Lin and Fu, 2017), negative (Woidtke, 2002; Ferreira and Matos, 2008), and no significant (Duggal and Millar, 1999) influence on firm performance. Moreover, many studies examine the role of institutional

[1] According to Corporate Responsibility Reporting 2017 conducted by KPMG, 67% of the leading global firms (G250) have already set up targets for reducing their carbon emissions.

investors in shaping various aspects of corporate decisions, such as R&D investment behaviour (Bushee, 1998), mergers and acquisitions (Chen et al., 2007; Fich et al., 2015), earnings management (Koh, 2003), stock price efficiency and stability (Dobbins and Greenwood, 1975; Shu, 2013); disclosure and information asymmetry (Jiang et al., 2011; Gietzmann and Isidro, 2013), corporate governance (Gillan and Starks, 2000, 2007; Aggarwal et al., 2011; McCahery et al., 2016), and executive compensation (Hartzell and Starks, 2003).

The studies that examine the relationship between institutional investors and corporate social responsibility (CSR) are fragmented and inconsistent. Such fragment and inconsistency are generally derived from the types and motives of institutional investors. For example, Johnson and Greening (1999) is one of the pioneer studies that examine the impact of institutional investors on CSR. The study classifies institutional investors into investment management funds (mutual funds and investment banks) and pension funds. The study shows a strong relationship between pension funds and CSR but no significant relationship between investment management funds and CSR. Hong and Kacperczyk (2009) show that norm-constrained institutions, i.e., pension plans compared to mutual or hedge funds, invest less in 'sin' industries (the alcohol, tobacco, and gambling industries), since these industries are harmful to society. Cox and Wicks (2011) find that dedicated institutions (in-house-managed public and private sector pension funds) invest in those firms that have greater CSR disclosures and demonstrate better CSR performance. Similarly, several other studies (Gloßner, 2019; Nguyen et al., 2020) document positive relationships between long-term investors and CSR activities. Recently, Erhemjamts and Huang (2019) find that institutions with longer (shorter) investment horizons promote (discourage) CSR, while Cheng et al. (2022) show that common institutional ownership is negatively associated with the level of CSR. A few studies (Harjoto et al., 2017; Chen et al., 2020) investigate the impact of aggregate institutional ownership and CSR. For instance, Harjoto et al. (2017) find that higher institutional ownership leads to better CSR ratings. Finally, Chen et al. (2020) find that institutional shareholders improve firm CSR performance in US's Russell index firms.

Prior work on the relationship between institutional ownership and environmental responsibility remains rare. For instance, Fernando et al. (2010) report that institutional ownership is significantly associated with firms' environmental engagement, suggesting that green firms attract more institutional investors. From a large sample of 41 countries, Dyck et al. (2019) show that institutional ownership is positively associated with environmental and social (E&S) performance. Very recently, Benlemlih et al. (2022) show that institutional ownership reduces Greenhouse Gas Emissions in the UK and the USA.

In general, however, the scope of prior studies on institutional investors and firm environmental performance has a major limitation. All the prior studies on the nexus institutional investors-firm environmental performance concentrate on aggregate institutional ownership. Nevertheless, they fail to address one vital question: do all institutional investors care about firm environmental performance? We expect that not all institutional investors promote corporate environmental performance since extant literature shows that only certain types of institutional ownership endorse firm social engagement. We aim to narrow this important gap in the extant literature by addressing the following important research questions. First, does aggregate institutional ownership affect carbon emissions? Second, does independent versus grey institutional investors affect carbon emissions? Third, do institutional investors' investment horizons affect carbon emissions? Fourth, does monitoring institutional investors affect carbon emissions? Answering these questions would add significant value to policy implications and knowledge creation.

2.2. Theoretical perspectives

There are three theoretical perspectives on the relationship between institutional investors and firm environmental performance. First, the active monitoring view suggests that institutional investors monitor firm business activities and decrease information asymmetry and agency problems, preventing firms from reputational image (Shiu and Yang, 2017). Moreover, institutional investors apply their highly developed managerial skills, professional knowledge, and voting rights to influence managers to undertake pro-social activities that develop a trustworthy relationship between firms and their major stakeholders. We argue that institutional investors are likely to play a proactive role in reducing carbon emissions, improving the firm reputational image and securing the insurance-like benefit. Such improved reputational image and insurance-like benefits provide a competitive advantage to firms when they experience an adverse shock in a crisis (Minor and Morgan, 2011; Lins et al., 2017) and long-term financial gains. In this connection, the natural resource-based view (Hart, 1995) also argues that a firm's competitive advantage is driven by its ability to employ resources to mitigate their impact on the environment (e.g., through abatement of carbon emissions), which leads to better financial performance compared to counterparts who are less proactive in such exertions (Michalisin and Stinchfield, 2010). The financial benefits from firm-specific competitive advantages offer a conducive platform with which institutional investors can encourage firm managers to adopt environmentally friendly business models, including those that significantly reduce carbon emissions.

Second, according to the "passive monitoring" view, institutional investors may be tempted by frequent trading and can be short-term-oriented (Wines, 1990). Considering carbon emissions requires a relatively long-term orientation, Jacobs (1991) and Porter (1992) argue that some institutional investors may prefer to be traders than owners, with a focus on short-term developments. Myopic institutional theory suggests that institutional shareholders tend to be highly motivated by short-term profits and tend to encourage business activities that bring returns immediately (Hansen and Hill, 1991). Consistent with this notion, institutional owners may not encourage activities conducive to the abatement of carbon emissions (Coffey and Fryxell, 1991) and no relationship or a weak relationship should be expected between them.

Third, the "exploitation" view argues that institutional investors may follow traditional objectives of the business, i.e., profit maximization through the exploitation of natural resources and the environment. Specifically, they may overlook or provide an implicit license to management to ignore the environmental consequences of business activities. Therefore, a negative relationship between firm carbon performance and institutional ownership would be manifested if management does not care environment. Overall, theoretical arguments highlight that the impact of institutional ownership on carbon emissions is indeterminate a priori.

3. Data and sample description

We use data from three sources. We collected institutional ownership data from the Thomson-Reuters Institutional Holdings database and the FactSet database. Carbon emissions data came from the Thomson-Reuters Eikon database, which also includes the ASSET4 database. We obtained control variables of this study such as sales growth, firm size, capital expenditure, leverage, R&D intensity, return on assets (ROA) and cash holdings[2] from the Thomson-Reuters Eikon database. We use firms' ISIN identifiers to merge the dataset obtained from these sources to construct a sample ranging in time from 2007 to 2017.

We employ a number of institutional ownership variables in our estimation. First, for our baseline analysis, we use total institutional ownership which is the institutional ownership in percentage of market capitalization. We then employ measures of independent and grey institutional investors. Following literature (e.g., Bushee, 1998; Chen et al., 2007), we categorize investment companies, investment advisors,

[2] Definitions for all variables are provided in Appendix Table A1.

and pension funds as independent institutional investors while other institutional investors such as banks and insurance companies are classified as grey or passive institutional investors. In our subsequent analysis, we use long-term and short-term institutional investors based on their investment horizon. We use churn rate and investor turnover to calculate investors' long and short horizons. In our final analysis, we employ monitoring institutional investors - a relatively new measure of institutional investors based on their portfolio weights, as developed by Fich et al. (2015). We provide further explanations of these measures in the respective sections.

We began our sample with all companies listed on the New York Stock Exchange for the period 2007—2017. We use non-zero carbon emission data to match 13-F and FactSet institutional ownership data and ended up with 2106 firms and 12,976 firm-year observations.[3] We started in 2007 because very few firm-year carbon emissions data are available for pre-2007 periods.[4] Table 1 provides the sample distribution. Panel A of Table 1 presents the year-wise sample distribution, which depicts that firm-year observations increased gradually between 2007 and 2014 and at a higher rate in 2015 and onwards compared to preceding years, which can be attributed to the higher disclosure of carbon emissions in recent years. In Panel B, the number of firms across industry sectors is reported, which suggests that our sample is representative of all GICS sectors.

Table 2 reports the descriptive statistics of all variables. Panels A-C present dependent variables, variables of interest, and control variables, respectively. The mean values of three carbon emissions proxies suggest that the total carbon emissions of firms are attributed more to direct carbon emissions compared to indirect carbon emissions.[5] It is worth mentioning that the sum of direct and indirect carbon emissions differ from the mean value of total emissions as component-wise disclosure of carbon data is unavailable for all firms. The average nitrogen oxide emissions in our sample firms is 59,494.78 t.

Regarding institutional ownership descriptive statistics, Panel B indicates that the average of institutional ownership is 39.3% in our studied firms. The averages of independent and grey institutional ownership are 37% and 2.2%, respectively. Our sample firms have 10.7% long-term institutional ownership, 43.3% short-term institutional ownership and 22.7% monitoring institutional ownership.

As for the control variables, in line with Gallego-Álvarez et al., 2015; and Liao et al., 2015), we expect a positive relationship between firm carbon emissions and sales growth as additional sales require more production, which results in higher carbon emissions. Firm size, measured by the logarithm of total assets, is controlled as carbon emissions increase when firms become larger and a positive association is expected (e.g., Lee and Min, 2015). Firms with higher capital expenditures may emit more carbon (Huq, 2017; Luo et al., 2012), and a positive relationship is expected with carbon emissions. Firms with a higher leverage ratio may have a higher obligation to pay the interest, and they may not be able to invest in environmental-friendly initiatives

Table 1
Sample distribution.

Panel A: Year-wise sample distribution			Panel B: GICS industry sector-wise sample distribution		
Year	Observations	% of observations	GICS Sector	No of firms	% of Sample firms
2007	725	5.59%	10	190	9.02%
2008	889	6.85%	15	179	8.50%
2009	975	7.51%	20	119	5.65%
2010	1026	7.91%	25	590	28.02%
2011	1041	8.02%	30	88	4.18%
2012	1046	8.06%	35	72	3.42%
2013	1060	8.17%	40	383	18.19%
2014	1083	8.35%	45	147	6.98%
2015	1485	11.44%	50	62	2.94%
2016	1813	13.97%	55	143	6.79%
2017	1833	14.13%	60	133	6.32%
Total	12,976	100.00%	Total	2106	100.00%

This table presents sample distribution of our study. Panel A reports year-wise sample distribution and Panel B shows industry-sector wise sample distribution. Our full sample covers 2007–2017, 2106 firms and 12,976 firm-year observations.

Table 2
Descriptive statistics.

Variables	Mean	Std. Dev.	Min	Max
Panel A: Carbon emissions variables				
Total carbon emissions (in tonnes)	4,085,679	16,800,000	2	336,000,000
Direct carbon emissions (in tonnes)	5,939,484	17,900,000	1	179,000,000
Indirect carbon emissions (in tonnes)	1,159,671	2,646,309	37	29,500,000
Nitrogen Oxide (NOx) emissions (in tonnes)	59,494.78	210,172.5	0.02	4,449,000
Panel B: Institutional ownership variables				
Total institutional investors' ownership (%)	0.393	0.417	0	1
Independent institutional investors' ownership (%)	0.370	0.395	0	0.997
Grey institutional investors' ownership (%)	0.022	0.040	0	0.905
Long-term institutional investors' ownership (%)	0.107	0.272	0	0.999
Short-term institutional investors' ownership (%)	0.433	0.400	0	0.999
Monitoring institutional investors' ownership (%)	0.227	0.307	0	0.999
Domestic institutional investors' ownership (%)	0.333	0.372	0.000	0.995
Foreign institutional investors' ownership (%)	0.060	0.122	0.000	0.993
Panel C: Control variables				
Sales growth (%)	7.712	23.279	−85.2	192.52
Firm size (log of total assets in million USD)	16.165	1.726	10.203	22.049
Capital expenditure (log in million USD)	0.218	1.50	−6.90	9.18
Leverage (%)	0.293	0.202	0	3.781
R&D Intensity	3.255	5.364	0	16.172
ROA (%)	5.482	8.090	−90.17	45.79
Cash holdings (log in million USD)	13.223	1.966	2.772	20.174
Energy consumption (log of GwH)	15.691	2.089	2.7160	21.864
Market value to common shares outstanding (ratio)	40.0496	36.376	0.019	390.25
Book value to common shares outstanding (ratio)	18.445	23.820	−75.92	363.719
Extraordinary earnings per share	2.0566	4.154	−47.52	60.52

This table presents descriptive statistics for all variables used in this paper. Panels A-C report our carbon emissions variables, institutional ownership variables and control variables, respectively. The descriptive statistics are calculated based on 12,976 firm-year observations for the period 2007–2017.

[3] Our sample arrives at 10,101 firm-year observations when we use all control variables in the regression estimates.

[4] The Thomson-Reuters Eikon (ASSET4) database started reporting carbon emissions data in 2004. Few observations were found in the initial years, from 2004 to 2006.

[5] For a detail's definition of direct and indirect carbon emissions, we refer to the guidelines developed by GHG Protocol. https://ghgprotocol.org/calculationg-tools-faq.

to reduce carbon emissions (De Villiers et al., 2011; Huq, 2017). Given the positive effects of R&D on growth (Freimane and Bāliņa, 2016; Minniti and Venturini, 2017), R&D may negatively influence firm environmental performance through the scale effects of larger production. Hence, we control our model with R&D intensity which is R&D expenditure deflated by net sales. Atif et al. (2021) find that firms' profitability has a positive effect on firm environmental performance and therefore, we take on ROA as a control. Finally, cash holdings has a significant impact on firms' carbon emissions (Alam et al., 2022), and we control it with cash and cash equivalents.

In Panel C of Table 2, descriptive statistics of control variables indicate that firms experienced an annual steady sales growth of 7.7%, while their average firm size (measured by the log of total assets) is 16.17. The mean for capital expenditure (log in million USD) and leverage are 0.218 and 29%, respectively. The average energy consumption is 15.69 Gigawatt hours (GwH). The definitions for all variables are provided in Appendix Table A1.

4. Empirical results

4.1. Does institutional aggregate ownership affect carbon emissions?

To empirically investigate the association between institutional ownership and carbon emissions, we estimate the effects of lagged levels of institutional ownership on carbon emissions. In doing so, we estimate the below fixed effect regression model of carbon emissions as a function of firms' institutional ownership and several control variables:

$$CEs_{it} = \alpha + \beta IO_{it-1} + \gamma Z_{it-1} + \epsilon_{it} \tag{1}$$

where CEs_{it} is the log of carbon emissions for a firm i in year t; IO_{it-1} is our proxy for institutional ownership in year $t-1$, measured as the percentage of total institutional ownership[6]; Z_{it-1} are a set of firm-level control variables in year $t-1$. We include in the empirical specification year and firm-fixed effects[7] and cluster the standard errors at the firm level.

In Table 3, we report empirical results. The dependent variable in columns (1) and (4) is total carbon emissions, in columns (2) and (5) is direct carbon emissions and is indirect carbon emissions in columns (3) and (6). Our interest variable is the measure of institutional ownership. Columns (1)— (3) demonstrate that firms having more institutional owners experience fewer carbon emissions. The impact of institutional ownership on carbon emissions is economically meaningful: an increase of one standard deviation in institutional ownership (0.417) corresponds to a 15.39 ($= 0.417 \times 0.3692$) percentage point decrease in total carbon emissions, a 20.69 ($= 0.417 \times 0.4962$) percentage point decrease in direct carbon emissions, and a 20.56 ($= 0.417 \times 0.4932$) percentage point decrease in indirect carbon emissions. One concern with the specifications reported in columns (1)— (3) is that the negative effect of institutional ownership on carbon emissions may be due to the omitted variables rather than the institutional ownership variable itself. In addressing this potential concern, in columns (4)— (6), we use a number of firm characteristics as control variables that our predecessors found relevant for firms' social and environmental performance (Chen et al., 2020; Dyck et al., 2019; Kim et al., 2019b). The results stated in columns (4)—(6) confirm that firms with more institutional owners have fewer carbon emissions. The magnitude of the effect in columns (4)—(6) is somewhat attenuated after controlling for firm-specific characteristics, however, the impact is still economically significant. For instance, column (4) reports an increase of one standard deviation in the institutional ownership is linked with a decline of 9.57 percentage points in total carbon emissions.

Next, we turn to the effects of control variables. Our results in columns (4)—(6) show that carbon emissions are higher in larger firms and in firms that experience higher sales growth and higher capital expenditure. Higher leverage increases and R&D intensity reduce carbon emissions, but the results are not robust across models. Firms with higher profitability and cash holdings emit less carbon.

4.2. Does independent versus grey institutional investors affect carbon emissions?

In section 4.1, we investigate the impact of aggregate institutional ownership on carbon emissions. One possible concern is that such a measure presumes institutional investors to be a cognate group with identical objectives. However, in practice, institutional investors tend to differ in their behaviour and incentives (Bushee, 1998; Chen et al., 2007). Some institutional investors (e.g., investment companies, investment advisors, and pension funds) may be active in gathering information and monitoring management for the long-run value, while others (e.g., banks and insurance companies) may have a passive role or a role as buy-and-hold-type investors (Bushee, 1998; Chen et al., 2007; Cornett et al., 2007; Dyck et al., 2019; Kim et al., 2019a). Chen et al. (2007) classify the former group as 'independent' and the latter group as 'grey' institutional investors. Unlike independent institutional investors, grey institutional investors maintain or pursue potential profit-yielding relationships with invested firms and tend to engage less in monitoring or challenging management decisions (Chen et al., 2007). Using prior research and guides on institutional ownership, we attempt to address this possibility by examining whether such investor groups have a differential effect on firms' carbon emissions. We argue that carbon emissions have the potential to be affected more by independent institutional investors than grey investors. To this end, we estimate Eq. (2), which replaces the aggregate measure of institutional investors in Eq. (1) with measures of institutional investor type:

$$CEs_{it} = \alpha + \beta IOtype_{it-1} + \gamma Z_{it-1} + \epsilon_{it} \tag{2}$$

where $IOtype_{it-1}$ is a measure of institutional investor type (independent institutional investors versus grey institutional investors). Table 4 contains our regression results. Panel A presents the role of independent institutional investors while Panel B focuses on grey institutional investors. As in Panel A, a greater number of independent institutional investors reduces firms' total carbon emissions, direct carbon emissions, and indirect carbon emissions. The effect of independent institutional investors is also economically important. For instance, a one standard deviation increase in independent institutional ownership (0.395) is associated with a 10.30 ($= 0.395 \times 0.261$) percentage point decrease in total carbon emissions, a 15.56 ($= 0.395 \times 0.394$) percentage point decrease in direct carbon emissions, and a 15.24 ($= 0.395 \times 0.386$) percentage point decrease in indirect carbon emissions. However, as expected, results in Panel B demonstrate that the total carbon emissions and direct carbon emissions are unaffected by grey institutional investors. The effect of grey investors is negative but marginally significant on indirect carbon emissions. These revelations unmask the influence of institutional investor types on carbon emissions. Our findings are consistent with the evidence found by prior studies, which show that independent institutional investors, unlike grey institutional investors, are conducive to improving firms' post-merger performance (Chen et al., 2007) and social and environmental performance (Kim et al., 2019b; Dyck et al., 2019). The effects of control variables are qualitatively similar to those reported in Table 3.

We further examine how each type of institutional investor affects total carbon emissions. More specifically, we disentangle the separate

[6] Following Nagel (2005), residual institutional ownership is used in the model estimation to purge the link between size and institutional ownership. The residual institutional ownership is the residual form of: $IO_{it} = \alpha + \beta Logsize_{it} + \gamma(Logsize_{it})^2 + \epsilon_{it}$. Hong et al. (2000) used this approach, which is similar to ours while Barinov (2017) in a different context than ours.

[7] In our estimations, we use GICS industry fixed effects dropping firm-fixed effects; and all results hold.

Table 3
Institutional investors and carbon emissions.

	TCE	DCE	INCE	TCE	DCE	INCE
	(1)	(2)	(3)	(4)	(5)	(6)
Total IO	**−0.3692***	**−0.4962***	**−0.4923***	**−0.2842***	**−0.4051***	**−0.3894***
	(−7.02)	**(−4.65)**	**(−3.92)**	**(−5.19)**	**(−3.73)**	**(−3.04)**
Sales growth				0.0003***	0.0010***	0.0007***
				(3.84)	(4.72)	(2.78)
Firms size				0.5542***	0.3916***	0.5570***
				(20.19)	(10.07)	(12.85)
Capital expenditure				0.1575***	0.1292***	0.0905***
				(14.49)	(6.92)	(4.08)
Leverage				0.0462***	0.0030	−0.1620
				(2.69)	(0.03)	(−1.22)
R & D intensity				−0.0007***	−0.0003	0.0004
				(3.55)	(−0.31)	(1.16)
ROA				−0.0004	−0.0031**	−0.0002
				(−0.48)	(−2.04)	(−0.01)
Cash holdings				−0.0398***	−0.0382***	−0.049***
				(−4.81)	(−3.20)	(−3.44)
Constant	12.451***	12.65***	12.66***	12.478***	12.772***	12.729***
R-squared	0.126	0.062	0.046	0.256	0.177	0.135
F-statistics	49.26***	21.65***	15.39***	49.31***	16.48***	7.32***
Year fixed effects	Y	Y	Y	Y	Y	Y
Firm fixed effects	Y	Y	Y	Y	Y	Y
Observations	12,976	4040	3821	10,101	4040	3821

***, ** and * indicate statistical significance at the 1%, 5% and 10% levels, respectively; and t-statistics are reported in parentheses. TCE is the total carbon emissions, DCE is the direct carbon emissions and INCE is the indirect carbon emissions.

Table 4
Independent vis-à-vis grey institutional investors and carbon emissions.

	Panel A: The role of independent institutional investors ownership (Independent IO)			Panel B: The role of grey institutional investors ownership (Grey IO)		
	TCE	DCE	INCE	TCE	DCE	INCE
	(1)	(2)	(3)	(1)	(2)	(3)
Independent IO	**−0.2617***	**−0.3793***	**−0.3835***			
	(−4.63)	**(−3.35)**	**(−2.84)**			
Grey IO				**−0.5342**	**0.2992**	**−0.7392***
				(−1.23)	**(1.63)**	**(−1.86)**
Sales growth	0.0003***	0.0010***	0.0007***	0.0003***	0.0010***	0.0007***
	(3.88)	(4.75)	(2.71)	(3.92)	(4.79)	(2.75)
Firms size	0.625***	0.391***	0.557***	0.626***	0.393***	0.556***
	(9.2)	(10.69)	(12.85)	(9.22)	(10.78)	(12.85)
Capital expenditure	0.1558***	0.1253***	0.0862***	0.1599***	0.1348***	0.0921***
	(14.48)	(6.82)	(3.93)	(14.89)	(7.38)	(4.22)
Leverage	0.0626	0.0058	−0.1439	0.0746	0.0301	−0.1438
	(0.93)	(0.05)	(−1.09)	(1.11)	(0.27)	(−1.08)
R & D intensity	0.0101**	0.0102*	0.0154**	0.0103**	0.0110*	0.0152**
	(2.31)	(1.78)	(2.20)	(2.34)	(1.91)	(2.17)
ROA	−0.0007	−0.0029*	−0.0001	−0.0008	−0.0031**	−0.0004
	(−0.84)	(−1.93)	(−0.06)	(−0.91)	(−2.04)	(−0.20)
Cash holdings	0.0917***	0.0381***	0.0638***	0.0944***	0.0401***	0.0661***
	(10.80)	(3.20)	(4.46)	(11.13)	(3.38)	(4.63)
Constant	11.2489***	12.1647***	11.7423***	11.1969***	12.1309***	11.7301***
R-squared	0.046	0.032	0.020	0.043	0.030	0.019
F-statistics	58.23***	16.42***	9.56***	55.25***	15.16***	8.89***
Year fixed effects	Y	Y	Y	Y	Y	Y
Firm fixed effects	Y	Y	Y	Y	Y	Y
Observations	10,101	4040	3821	10,101	4040	3821

***, ** and * indicate statistical significance at the 1%, 5% and 10% levels, respectively; and t-statistics are reported in parentheses. TCE is the total carbon emissions, DCE is the direct carbon emissions and INCE is the indirect carbon emissions.

effect of independent institutional investors (e.g., investment companies, investment advisors, and pension funds) and grey institutional investors (banks and insurance companies). The findings are presented in Appendix Table A2. Panels A and B report that investment companies and investment advisors contribute more to reducing firms' carbon emissions than all other types of investors. As before, we find that grey institutional investors, specially bank and insurance companies, have no effect on firms' carbon emissions. The results further depict that total carbon emissions in firms are influenced more by independent than grey institutional investors, which supports our results as presented in Table 4.[8]

[8] We also examine the effect of ownership by institutional investor type on direct and indirect carbon emissions. The results remain unchanged.

Table A2 Institutional investors and total carbon emissions: The role of specific type of institutional investors ownership.

	Panel A: The role of specific independent institutional investors			Panel B: The role of specific grey institutional investors	
	Model 1	Model 2	Model 3	Model 1	Model 2
Independent IO by investment companies	**−0.5442*** (−3.84)**				
Independent IO by investment advisors		**−0.2089*** (−2.65)**			
Independent IO by pension funds and endowments			**−0.5001* (−1.73)**		
Grey IO by banks				**−0.9687 (−1.06)**	
Grey IO by insurance companies					**−0.6388 (−0.22)**
Sales growth	0.0003*** (3.90)	0.0003*** (3.90)	0.0003*** (3.93)	0.0003*** (3.88)	0.0003*** (3.92)
Firms size	0.3163*** (9.24)	0.3222*** (9.28)	0.3281*** (9.59)	0.3301*** (9.56)	0.3190*** (9.35)
Capital expenditure	0.1594*** (14.86)	0.1579*** (14.67)	0.1599*** (14.89)	0.1607*** (14.95)	0.1600*** (14.90)
Leverage	0.0782 (1.17)	0.0637 (0.95)	0.0739 (1.10)	0.0837 (1.24)	0.0762 (1.14)
R & D intensity	0.0099** (2.26)	0.0103** (2.35)	0.0103** (2.34)	0.0102** (2.32)	0.0102** (2.33)
ROA	−0.0007 (−0.86)	−0.0007 (−0.86)	−0.0008 (−0.89)	−0.0008 (−0.91)	−0.0008 (−0.88)
Cash holdings	0.0937*** (11.06)	0.0924*** (10.87)	0.0943*** (11.13)	0.0944*** (11.13)	0.0941*** (11.11)
Constant	11.2141***	11.2300***	11.1967***	11.1921***	11.1970***
R-squared	0.045	0.044	0.043	0.043	0.043
F-statistics	57.23***	56.08***	55.22***	55.20***	55.03***
Year fixed effects	Y	Y	Y	Y	Y
Firm fixed effects	Y	Y	Y	Y	Y
Observations	10,101	10,101	10,101	10,101	10,101

***, ** and * indicate statistical significance at the 1%, 5% and 10% levels, respectively; and t-statistics are reported in parentheses.

4.3. Do institutional investors' investment horizons affect carbon emissions?

In this section, we examine whether carbon emissions are affected by the institutional investors' investment horizons. Such an examination is motivated by the fact that institutional investors are different based on their investment horizons. Some institutional investors pursue a short-term horizon for their investment, while others have a long-term investment horizon. This difference in investment horizons may result in differences in their monitoring incentives, which in turn may affect firms' carbon emissions. Short-term institutional investors tend to focus on quick, short-term trading profits leading to managerial short-termism or myopic business decisions (Gaspar et al., 2005). By contrast, institutional investors with long-term horizons influence managers to pursue agendas or invest in projects that seek long-term maximization of firm value (Gaspar et al., 2005; Kim et al., 2019a). Carbon abatement is likely to be associated with the greater firm value in the long run. Building on this, we conjecture that firms having institutional investors who maintain longer investment horizons will have reduced carbon emissions compared to their counterparts.

As in Gaspar et al. (2005), we use churn rate and investor turnover to calculate investors' horizons. Investors with short-horizon trade their shares more often, while long-horizon investors keep their positions unchanged for a reasonably long period. To instrument this idea empirically, we first determine churn rate for each of the institutional investors, which measures how often an investor exchanges the securities of their portfolio. Churn rate is calculated as:

$$CR_{it} = \frac{\sum_{j\in Q}\left|N_{jit}P_{jt} - N_{jit-1}P_{jt-1} - N_{jit}\Delta P_{jt}\right|}{\sum_{j\in Q}\frac{\left|N_{jit}P_{jt}+N_{jit-1}P_{jt-1}\right|}{2}} \tag{3}$$

where CR_{it} is the churn rate, Q is the set of companies held by investor i. P_{jt} and N_{jit} represent the price and the number of shares, respectively, of firm j held by institutional investor i at quarter t.

Next, we use investor churn rates to estimate a measure of investor turnover for each firm that measures the investment horizons of institutional shareholders. The investor turnover of firm k is the weighted average of the total portfolio churn rates of its investors over four quarters:

$$Investor\ turnover_k = \sum_{i\in S} w_{kit}\left(\frac{1}{4}\sum\nolimits_{r=1}^{4} CR_{it-r+1}\right) \tag{4}$$

where S denotes the set of shareholders in firm k, w_{kit} denotes the weight of investor i in the total percentage held by the institutional investors at quarter t. A higher turnover implies a relatively shorter investment horizon, while a lower turnover indicates a relatively longer investment horizon. We measure the ownership of long- or short-term institutional investors as a percentage of total institutional ownership, where long-term or short-term institutional investors are defined as investors whose turnover ratio is in the bottom or top tercile.

To test the assertion that investment horizons of institutional investors may influence firms' carbon emissions, we use the following model:

$$CEs_{it} = \alpha + \beta_1 Long-term\ IO_{it-1} + \beta_2 Short-term\ IO_{it-1} + \beta_3 Turnover_{it-1} + \beta_4 Z_{it-1} + \epsilon_{it} \tag{5}$$

where $Long-term\ IO_{it-1}$ is the long-term institutional ownership as a percentage of total institutional ownership, $Short-term\ IO_{it-1}$ is the short-term institutional ownership as a percentage of the total institutional ownership, *Turnover* is the institutional investor turnover. We use three versions of the model in Eq. (5), and in each version, we use one of the three variables: long-term institutional ownership, short-term institutional ownership, and institutional investor turnover as the variable of interest.

Table 5 reports empirical results. The results reveal that firms with

Table 5
Institutional investors Investment horizons and carbon emissions.

	Panel A: TCE			Panel B: DCE			Panel C: INCE		
	(1)	(2)	(3)	(1)	(2)	(3)	(1)	(2)	(3)
Long-term IO	**-0.1715***** **(−2.61)**			**−0.1639**** **(−2.27)**			**−0.0475** **(−0.82)**		
Short-term IO		**0.064** **(0.16)**			**−0.1075** **(−1.44)**			**−0.0499** **(−0.59)**	
Turnover			**0.1291**** **(2.07)**			**0.1165*** **(1.86)**			**−0.0037** **(−0.17)**
Sales growth	0.0003*** (3.94)	0.0002*** (2.96)	0.0003*** (3.24)	0.0009*** (4.21)	0.0001 (0.24)	0.0008*** (3.94)	0.0005** (2.08)	0.0001 (0.19)	0.0004* (1.66)
Firms size	0.5646*** (7.94)	0.5496*** (25.36)	0.5803*** (27.99)	0.4024*** (9.89)	0.3192*** (8.10)	0.3408*** (9.97)	0.4784*** (10.22)	0.4398*** (9.88)	0.4784*** (11.61)
Capital expenditure	0.1606*** (14.97)	0.0236** (1.98)	0.0318*** (2.78)	0.0161 (0.73)	0.1121*** (5.12)	0.0315 (1.54)	−0.0393 (−1.54)	0.1180*** (4.67)	−0.0460* (−1.87)
Leverage	0.0657 (0.98)	−0.0753 (−1.10)	−0.1306** (−1.99)	−0.0618 (−0.52)	−0.0587 (−0.47)	−0.0901 (−0.81)	−0.2468* (−1.82)	−0.2195 (−1.56)	−0.2860** (−2.17)
R & D intensity	0.0099** (2.26)	0.0095** (2.13)	0.0053 (1.26)	0.0167** (2.54)	0.0139* (1.86)	0.0073 (1.31)	0.0287*** (3.57)	0.0101 (1.17)	0.0114* (1.66)
ROA	−0.0008 (−0.93)	0.0002 (0.19)	0.0002 (0.26)	−0.0027* (−1.78)	−0.0023 (−1.31)	−0.0010 (−0.67)	0.0007 (0.38)	−0.0019 (−0.95)	0.0015 (0.83)
Cash holdings	0.0940*** (11.09)	0.0048 (0.55)	0.0038 (0.43)	0.0095 (0.69)	0.0290** (2.19)	−0.0041 (−0.33)	0.0003 (0.02)	0.0693*** (4.54)	−0.0009 (−0.06)
Constant	11.2040***	3.6314***	3.1954***	5.6685***	12.3388***	7.0532***	4.4542***	11.7278***	4.6256***
R-squared	0.044	0.145	0.126	0.064	0.016	0.056	0.055	0.021	0.056
F-statistics	56.10***	122.17***	147.83***	23.99***	5.72***	24.83***	19.70***	7.08***	23.78***
Year fixed effects	Y	Y	Y	Y	Y	Y	Y	Y	Y
Firm fixed effects	Y	Y	Y	Y	Y	Y	Y	Y	Y
Observations	10,087	10,087	10,087	3360	3360	3360	3231	3231	3231

***, ** and * indicate statistical significance at the 1%, 5% and 10% levels, respectively; and t-statistics are reported in parentheses. TCE is the total carbon emissions, DCE is the direct carbon emissions and INCE is the indirect carbon emissions.

more long-term institutional investors emit less total and direct carbon compared to their peers with fewer long-term institutional investors. The effect size is also qualitatively similar to total carbon emissions and direct carbon emissions. The effect on indirect carbon emissions is statistically insignificant. However, we unearth that the effect of short-term institutional investors is insignificant across the models, suggesting that firms' carbon emissions are unaffected by short-term institutional investors. This finding is not surprising because this group of investors focuses more on short-term trading profits rather than long-term value-enhancing activities. Our finding is in line with prior studies that examine the effect of investors' horizons in a different context (Bushee, 1998; Gaspar et al., 2005; Gloßner, 2019; Kim et al., 2019a).

Table 6
Monitoring institutional investors and carbon emissions.

	TCE	DCE	INCE
	(1)	(2)	(3)
Monitoring IO	**−0.1661***** **(−5.66)**	**−0.1088***** **(−2.93)**	**−0.1276***** **(−5.25)**
Sales growth	0.0003*** (3.32)	0.0009*** (4.03)	0.0004 (1.47)
Firms size	0.5645*** (27.98)	0.3169*** (9.29)	0.4620*** (11.45)
Capital expenditure	0.0367*** (3.29)	0.0477** (2.36)	−0.0281 (−1.18)
Leverage	−0.1065* (−1.65)	−0.0214 (−0.19)	−0.1492 (−1.14)
R & D intensity	0.0059 (1.41)	0.0082 (1.43)	0.0133* (1.94)
ROA	0.0004 (0.44)	−0.0016 (−1.05)	0.0017 (0.98)
Cash holdings	0.0085 (0.98)	−0.0017 (−0.13)	0.0052 (0.35)
Constant	3.3518***	7.3582***	4.7171***
R-squared	0.127	0.055	0.065
F-statistics	154.84***	25.37***	28.25 ***
Year fixed effects	Y	Y	Y
Firm fixed effects	Y	Y	Y
Observations	10,090	4035	3816

***, ** and * indicate statistical significance at the 1%, 5% and 10% levels, respectively; and t-statistics are reported in parentheses.
TCE is the total carbon emissions, DCE is the direct carbon emissions and INCE is the indirect carbon emissions.

4.4. Does monitoring institutional investors affect carbon emissions?

In this section, we investigate if monitoring institutional investors matter in reducing carbon emissions. Although institutional investors' monitoring incentives reflect in the style of investor (e.g., independent or grey investors in section 3.2) and their investment horizons (in section 3.3), we employ a relatively new measure of monitoring institutional investors based on their portfolio weights, as devised by Fich et al. (2015). This proxy of monitoring institutional investors has also been used in other studies to examine the effect on pay-out and performance (Nagel et al., 2015), managerial efficiency (Baghdadi et al., 2018), and the marginal value of cash (Ward et al., 2018). To the best of our knowledge, no previous studies have assessed the impact of carbon emissions. In this section, we further investigate if our findings in section 3.1 are driven by institutional investors who are motivated to exert monitoring efforts on firms due to their large portion of equity holding value.

Institutional investors generally have multiple holdings across firms, and the allocation of their monitoring efforts to each firm is motivated by the relative significance of the firm's stock in their portfolio. The beneficial effect of monitoring a firm that signifies a small part of an institutional investor's total portfolio differs from that of monitoring a firm that has a large allocation of funds in their portfolio (Fich et al., 2015). Large stockholdings and high sophistication in institutional owners allow them to monitor managers' behaviour towards long-term goals and guard against short-termism (Monks and Minow, 1995). Additionally, monitoring activities, such as gathering and processing information and implementing actions, are costly, and institutions have limited resources for monitoring. It is therefore expected that institutions will allocate more monitoring efforts to firms with higher weights in their portfolios.

In line with the procedure advanced by Fich et al. (2015), we calculate the total ownership of monitoring institutions as a fraction of the firm's total shares outstanding, where monitoring institutional investors are defined as those institutions whose holding value in the firm is in the top decile of their portfolio. To do so, we estimate Eq. (6), which replaces the measure of total institutional investors in Eq. (1) with the monitoring institutional investors' ownership measure (*Monitoring* IO_{it-1}):

$$CEs_{it} = \alpha + \beta Monitoring\ IO_{it-1} + \gamma Z_{it-1} + \epsilon_{it} \tag{6}$$

In Table 6, our results from estimating Eq. (6) are reported. The findings in Panel A indicate that the proxy for monitoring institutional ownership attains a negative and significant coefficient. The effect size is economically meaningful since an increase of a single standard deviation in ownership by monitoring institutions lowers total carbon emissions by 4.8%. The results remain valid in Panels B and C, where Eq. (6) is re-estimated using two other proxies for carbon emissions as the dependent variable. Our results in Table 6 are more compelling compared to those presented in Table 5. This is because, unlike the insignificant effect of long-term investors on indirect carbon emissions (Panel C of Table 5), the impact of monitoring institutional ownership is found to be meaningful both in a statistical and economic sense for both direct and indirect carbon emissions. This result can be interpreted as the outcome of the oversight of monitoring institutions, which persuades firms to undertake initiatives to reduce all forms of carbon emissions.[9],[10]

5. Addressing endogeneity

Our findings support the notion that institutional investors reduce carbon emissions. Our results are robust, with the inclusion of alternative proxies for the ownership of institutional investors and total carbon emissions decomposition, as well as the inclusion of firm-fixed effects and lagged independent variables. Although the use of lagged independent variables and firm-fixed effects addresses endogeneity issues, the concern of causality between institutional ownership and carbon emissions persists. Therefore, we use a quasi-natural experiment and the difference-in-differences approach to address this endogeneity concern.

5.1. Do institutional investors affect carbon emissions? A quasi-natural experiment

To address the causality between institutional investors and carbon emissions, the BP Deepwater Horizon oil spill event that occurred in 2010, is employed as a quasi-natural experiment. This exogenous shock may influence institutional investors' decisions regarding environmental issues such as carbon emissions. This is a plausibly exogenous shock and may affect firms in various industries (e.g., oil, gas, coal and other extractives) as these firms affect environment quality (Dyck et al., 2019). Such an exogenous shock may also impact institutional investors' decisions in incorporating environmental factors into both their investment process and equity portfolio construction. Therefore, we expect a post-event variation in the focus of institutional investors on carbon emissions.

Empirically, we employ the DiD approach following Bertrand et al., 2004; Dyck et al., 2019 to estimate Eq. (7) below:

$$CEs_{it} = \alpha + \delta_1 IO_{it-1} + \delta_2 Post\ event + \delta_3 Treated\ firm_{it} + \delta_4 IO_{it-1} \times Post\ event \times Treated\ firm_{it} + \delta_5 Z_{it-1} + \epsilon_{it} \tag{7}$$

where *Post event* is a dummy variable for the post oil spill event period, 2011–2017. *Treated firm* is a dummy variable that includes firms belong to the extractive industries (Oil, Gas, Coal and related services) and other highly polluting industry sectors such as materials and utilities. Our coefficient of interest is δ_4 for the triple interaction term $IO_{it-1} \times$ *Post event* $\times$ *Treated firm*$_{it}$, which captures the post-event difference in institutional investors' effects on carbon emissions between treated and control firms.

The results are reported in Table 7. Panels A-F indicate that firms associated with more independent, long-term, and high-monitoring institutional investors experience lower total carbon emissions. The coefficients on post-event are negative and mostly significant, which suggests that carbon emission was reduced in the post-Deepwater Horizon oil spill periods.[11] The coefficients on treated firms are significantly positive across models, indicating that carbon emissions are higher in treated firms. Our triple interaction coefficients ($IO_{it-1} \times$ *Post event* $\times$ *Treated firm*$_{it}$) are negative and significant when we use institutional ownership proxies by independent, long-term, and monitoring institutions. The coefficient is statistically insignificant with the use of total ownership, grey ownership, and short-term ownership of institutional investors. Together, we find evidence that this exogenous environmental shock augment independent, long-term, and monitoring institutional investors' focus on reducing carbon emissions.

5.2. Institutional investors and carbon emissions: Difference-in-difference estimates

We also use a difference-in-difference estimation to address the potential causality between carbon emissions and institutional ownership. To this end, we use the mandatory cap-and-trade programme of the Regional Greenhouse Gas Initiative (RGGI) under a framework of difference-difference analysis. The mandatory cap-and-trade programme was employed to reduce carbon emissions from the power sector at the state level in the U.S. A total of nine states are currently participating in this program, including New York (NY), Maryland (MD), Delaware (DE), Connecticut (CT), Vermont (VT), Maine (ME), New Hampshire (NH), Rhode Island (RI), Massachusetts (MA), and The RGGI program initially started in 2005 with targets set for 2020 and 2030 to help the states reduce annual power-sector carbon emissions by a significant proportion. However, in 2012 the RGGI employed a 4-year

[9] We also investigate the role of domestic vs foreign institutional investors in influencing carbon emissions. Our untabulated results show that the effect of domestic institutional investors is more pronounced on carbon emissions reduction than foreign institutional investors.

[10] We also examine whether institutional investors are cautious about firm *NOx (Nitrogen Oxide) emissions* as NOx is widely documented as a factor that also leads to GHG emissions. To do so, we re-estimate Sections 3.1–3.4 by changing the dependent variable to the log of NOx emissions. Our untabulated results confirm that institutional ownership, measured by total, independent, long-term, and high-monitoring institutions, positively influences the reduction of NOx emissions.

[11] Our sample dataset on carbon emissions also shows that carbon emissions in treated firms are lower in the post-2010 period compared to pre-2010. Our results are qualitatively similar with the proxies of direct and indirect carbon emissions. To conserve space results are not tabulated.

Table 7
Institutional investors and carbon emissions: A quasi-natural Experiment.

	Panel A (IO is the Total IO)	Panel B (IO is the Independent IO)	Panel C (IO is the Grey IO)	Panel D (IO is the long-term IO)	Panel E (IO is the short-term IO)	Panel F (IO is the Monitoring IO)
Institutional investors' ownership (IO)	−0.2944***	−0.0586	0.7103*	−0.0538**	0.0366	−0.1261***
	(−5.84)	(−1.05)	(1.77)	(−1.99)	(1.30)	(−3.25)
Post event	−0.1051***	−0.1052***	−0.1036***	−0.1066***	−0.0148	−0.1056***
	(−8.36)	(−8.36)	(−8.21)	(−8.49)	(−1.14)	(−8.40)
Treated firms	2.3994***	2.3993***	2.3957***	2.3905***	2.3088**	2.3978***
	(3.24)	(3.24)	(3.18)	(3.09)	(2.24)	(3.23)
Total IO × Post event × Treated firms	**−0.0931***	**−0.0933***	**−0.7622**	**−0.2194*****	**0.1736**	**−0.0243****
	(−1.72)	**(−1.73)**	**(−1.59)**	**(−2.76)**	**(1.63)**	**(−2.50)**
Firm size	0.6118***	0.6111***	0.6136***	0.6136***	0.6136***	0.6044***
	(4.96)	(4.90)	(5.27)	(5.27)	(5.27)	(34.33)
Sales growth	0.0003***	0.0003***	0.0003***	0.0003***	0.0004***	0.0003***
	(3.13)	(3.13)	(3.23)	(3.21)	(3.61)	(3.17)
Capital expenditure	0.0968***	0.0969***	0.0961***	0.0967***	0.2293***	0.0968***
	(8.99)	(9.00)	(8.93)	(8.99)	(20.87)	(9.00)
Leverage	0.0650	0.0643	0.0623	0.0529	0.2042***	0.0600
	(1.02)	(1.01)	(0.98)	(0.84)	(2.95)	(0.95)
R & D intensity	0.0172***	0.0172***	0.0168***	0.0169***	0.0204***	0.0168***
	(4.57)	(4.57)	(4.48)	(4.49)	(5.07)	(4.47)
ROA	0.0011	0.0012	0.0011	0.0011	−0.0011	0.0012
	(1.30)	(1.32)	(1.21)	(1.24)	(−1.18)	(1.37)
Cash holdings	0.0126	0.0127	0.0126	0.0127	0.1396***	0.0128
	(1.47)	(1.48)	(1.46)	(1.48)	(16.47)	(1.48)
Constant	1.7216***	1.7312***	1.6908***	1.6955***	9.5600***	1.8369***
	(6.86)	(6.90)	(6.80)	(6.81)	(79.50)	(7.27)
Year and Firm fixed effects	Y	Y	Y	Y	Y	Y
R-squared	0.3541	0.3543	0.3462	0.3467	0.3465	0.3601
F-statistics	1414.47***	1415.48***	1369.90***	1374.36***	1368.38***	1468.85***

***, ** and * indicate statistical significance at the 1%, 5% and 10% levels, respectively; and t-statistics are reported in parentheses.

Table 8
Institutional investors and carbon emissions: Difference-in-Difference (DiD) approach with the *RGGI* of the New-England and Mid-Atlantic States of the US.

	Panel A (IO is the Total IO)	Panel B (IO is the Independent IO)	Panel C (IO is the Grey IO)	Panel D (IO is the long-term IO)	Panel E (IO is the short-term IO)	Panel F (IO is the Monitoring IO)
Institutional investors' ownership (IO)	0.1128	−0.1138**	0.7072	−0.0574**	0.0610	−0.059**
	(0.65)	(−2.06)	(0.66)	(−2.10)	(1.14)	(−2.33)
Post	−0.0782**	−0.1026***	−0.1171***	−0.1018***	−0.0759**	−0.1052***
	(−2.50)	(−3.42)	(−4.13)	(−3.37)	(−2.33)	(−3.49)
Treated firms	2.8130***	2.5466***	2.5298***	2.5617***	2.8643***	2.5512***
	(6.87)	(6.47)	(6.46)	(6.49)	(5.77)	(6.46)
Total IO × Post × Treated firms	**−1.3493*****	**−0.7082***	**−3.4044**	**−0.5508****	**0.2476**	**0.5397**
	(−3.08)	**(−1.94)**	**(−0.71)**	**(−2.13)**	**(0.24)**	**(0.55)**
Firm size	0.5012***	0.5275***	0.5935***	0.5236***	0.5107***	0.5267***
	(11.51)	(13.53)	(14.73)	(13.35)	(11.58)	(13.44)
Sales growth	0.0001	0.0002	0.0003*	0.0002	0.0003	0.0002
	(0.26)	(1.59)	(1.72)	(1.51)	(0.43)	(1.53)
Capital expenditure	0.1314***	0.0394**	0.0391*	0.0424**	0.0585***	0.0462***
	(6.16)	(2.22)	(1.94)	(2.40)	(3.33)	(2.62)
Leverage	0.1138	0.0058	0.0396	−0.0413	0.0101	−0.0570
	(0.97)	(0.06)	(0.37)	(−0.44)	(0.08)	(−0.62)
R & D intensity	0.0538***	0.0339***	0.0538***	0.0343***	0.0292***	0.0365***
	(5.37)	(3.96)	(5.86)	(4.02)	(3.00)	(4.25)
ROA	−0.0007	0.0024	0.0022	0.0014	0.0009	0.0015
	(−0.26)	(1.12)	(0.91)	(0.63)	(0.38)	(0.68)
Cash holdings	0.1646***	0.0132	0.0078	0.0110	−0.0151	0.0104
	(7.10)	(0.63)	(0.33)	(0.52)	(−0.66)	(0.50)
Constant	8.6599***	2.5749***	1.5034***	2.6510***	3.0963***	2.6102***
	(27.48)	(4.61)	(2.64)	(4.70)	(4.71)	(4.63)
Year and Firm fixed effects	Y	Y	Y	Y	Y	Y
R-squared	0.3998	0.4004	0.4213	0.3950	0.3969	0.4002
F-statistics	184.10***	355.75***	413.10***	420.18***	250.62***	344.42***
Observations	1072	968	1072	956	596	957

***, ** and * indicate statistical significance at the 1%, 5% and 10% levels, respectively; and t-statistics are reported in parentheses.

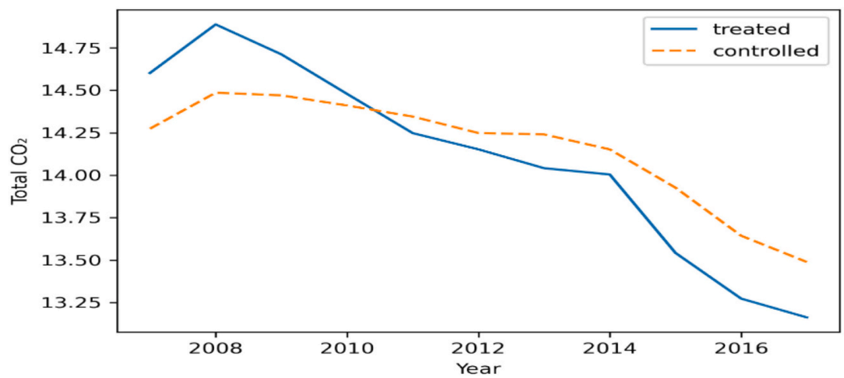

Fig. 1. Parallel-trend condition: Deepwater Horizon oil spill event in 2010.

lower cap of carbon allowance: 165 million tonnes, from an initial regional carbon cap of 188 million tonnes. They also introduced new procedures and standards for quarterly carbon allowance auctions and new parameters for tracking acquisition and transfers of carbon allowances through the RGGI Carbon Allowance Tracking System, along with conditions for attesting the eligibility of offset credits. These changes are viewed as a major pressure on the participating states and concerned firms to reduce carbon emissions. Motivated by the major changes in RGGI's carbon emissions targets and initiatives, we conduct a difference-in-difference analysis. Such a significant change to the carbon emissions policy may also impact institutional investors' decisions in those nine states in incorporating carbon emissions into both their investment process and equity portfolio construction. For our estimation purposes, we consider power sector firms operating in those nine states as treatment firms and all other firms as control firms. Following the standard method in prior studies (Bertrand et al., 2004; Dyck et al., 2019), we use the DiD technique to estimate Eq. (8) for the sample firms of nine U.S. states:

$$CEs_{it} = \alpha + \delta_1 IO_{it-1} + \delta_2 Post + \delta_3 Treated\ firm_{it} + \delta_4 IO_{it-1} \times Post \times Treated\ firm_{it} + \delta_5 Z_{it-1} + \epsilon_{it} \tag{8}$$

where *Post* is a dummy variable equal to one indicating whether firm i in year t is observed in the post-period of RGGI's change, 2013–2017, and zero otherwise. *Treated firm* is a dummy variable equal to one if a firm is a treated firm and zero otherwise. Our coefficient of interest is δ_4 for the triple interaction term $IO_{it-1} \times Post \times Treated\ firm_{it}$, which captures the post-event difference in institutional investors' effect on carbon emissions between treated and control firms. The findings are reported in Table 8. Panels A-F indicate that our treated firms with more independent, long-term, and monitoring institutional investors experienced lower total carbon emissions. The coefficients on post suggest that carbon emissions reduced in post-change periods. The coefficients on treated firms are significantly positive across models, indicating that carbon emissions are higher in treated firms. Our triple interaction coefficients ($IO_{it-1} \times Post \times Treated\ firm_{it}$) are negative and significant when we use institutional ownership proxies by total ownership, independent ownership, and long-term ownership but insignificant for other investor types. These results confirm that the change in RGGI's carbon emissions guidelines affects institutional investors' decisions about carbon emissions in treated firms located in those nine U.S. states.

5.3. Institutional investors and carbon emissions: The parallel- trend condition

The identification of the difference-in-differences method relies on the parallel-trend condition; that is, outcome variables move in parallel trends in the absence of the treatment. Although the parallel-trend condition is not testable, we follow Roberts and Whited (2013) and Chu (2021) to conduct a visual examination of the condition by plotting the outcome variable, carbon emissions, of the treated and control firms over the 10-year window. As we employ the BP Deepwater Horizon oil spill as our event in the first place, 2010 is our event year, 2007–2009 are the pre-event years, and 2011–2017 are the post-event years. Fig. 1 represents the visual examination of the parallel trend condition. Fig. 1 shows that carbon emissions of control and treated firms tend a follow a similar pattern before the event; that is, carbon emissions are higher in treated firms, and it reduced less than in control firms. After 2010, both treated and control firms continued their trend of declining emissions as it was before the event. However, the treated firms' carbon emissions decreased much faster after the event, which is consistent with the regression estimates of Model (7) and results in Table 7 that after the Deepwater Horizon oil spill, the role of institutional investors on carbon emissions is more pronounced.

In Fig. 2, we represent the visual examination of the parallel trend condition when the 2012 mandatory cap-and-trade program employed by the Regional Greenhouse Gas Initiative (RGGI) in the U.S is used in the DiD estimates. To this end, 2012 is our event year, 2007–2011 are the pre-event years, and 2013–2017 are the post-event years. Fig. 2 shows that carbon emissions of control and treated firms tend a follow a similar pattern before the event; that is, carbon emissions are higher in treated firms, and it reduced less than in control firms. After 2012, both treated and control firms continued their trend of declining emissions as it was before the event. However, the treated firms' carbon emissions decrease at a much faster pace after the event, which is consistent with the regression estimates of Model (8) and results in Table 8 that after the mandatory cap-and-trade program employed by the RGGI in the U.S, the effect of institutional investors on carbon emissions becomes more evident.

6. Additional tests

6.1. Institutional investors and carbon emissions: Alternative measure of carbon emissions

In this section, we re-estimate our baseline regression model using an alternative proxy of carbon emissions. We primarily use the log of carbon emissions as our dependent variable and for robustness test here, we employ an alternative proxy measured as total carbon emissions scaled by total sales revenues following prior literature (Jung et al., 2018;

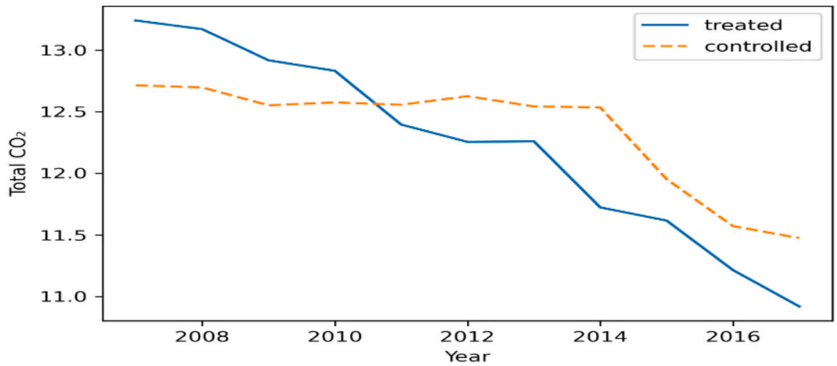

Fig. 2. Parallel-trend condition: 2012 mandatory cap-and-trade program employed by the RGGI in U.S.

Safiullah et al., 2021). We present the results in Appendix A3. Our results depict that institutional investor help reduce carbon emissions, but this result does not hold for all institutional investors. Particularly, grey and short-term institutional investors do not benefit firms by reducing carbon emissions. This result confirms our previous results reported in Tables 3-6. Thus, our main results are robust with alternative measures of carbon emissions.[12]

6.2. Institutional investors and carbon emissions by firm size

The exposure to carbon emissions risk has financial and social implications for investors, and thus, institutional investors are likely to monitor carbon abatement in their invested firms regardless of size. However, larger firms are likely to emit more carbon due to their large-scale operations or production. To this end, institutional investors are expected to pay more attention to the carbon abatement policies of larger firms. Empirically, we examine this assertion by creating a subsample of larger and smaller firms based on the median value of firm size. More specifically, larger firms are those that have a firm size greater than the median firm size of the entire sample, and smaller firms are those that have a firm size smaller than the median firm size of the entire sample. We estimate our model (1) separately for both larger and smaller firms. Appendix Table A4 shows the results. Panels A and B show that the effect of institutional investors on carbon emissions is negative both for larger and smaller firms. Together, these results suggest that institutional investors care about carbon emissions reduction for all firms in which they make investments, regardless of their size.

6.3. Institutional investors and carbon emissions: Industry effects

In the previous sections, we use year and firm fixed effects in all our empirical estimations. In this section, we account for the industry effects in our estimations due to the heterogeneity in nature and business operations among firms across industries. We tackle this issue by employing four approaches. In our empirical model (1), we control for industry effects, industry by time trend effects and industry by state effects. Finally, we estimate model (1) separately for 11 GICS industry sectors. These estimations help to account for the industry- related effects in our results and if there is any divergence in the effect of institutional investors on carbon emissions across industries.

We present empirical results in Appendix Table A5. Panel A reports that carbon emission is negatively associated with institutional investors. The result is robust with all three measures of carbon emissions. This result is also consistent with our main result, as reported in Table 3, indicating that the main result is robust and unaffected by the industry controls. In Panels B and C, we re-estimate our model (1) by controlling the industry by state fixed effects and industry by time trend fixed effects, respectively. We conduct this to account for the potential effect of state-wise divergence in policies and regulations in the U.S.A and to examine the time trend's impact on our findings. We find consistent evidence that institutional investors contribute to reducing carbon emissions.

Additionally, we examine the effect of institutional investors on carbon emissions by the industry sector. To this end, we divide our entire sample into 11 GICS industry sectors and estimate our model (1) separately for each sector. We do so to understand whether the effect of institutional investors varies across industries due to the difference in nature of business operations across industry sectors. Appendix Table A6 presents our results. Our results show that institutional investors significantly influence carbon emissions reduction in all industry sectors except consumer staples. Hence, the negative effect of institutional investors on carbon abatement is evident in our industry sector-wise results.[13] We further re-estimate our main results excluding the consumer discretionary industry sector (GICS 25) that represents 28% of our sample. As presented results in the last column of Appendix Table A6, our main result holds even after excluding GICS industry sector 25.

6.4. Institutional investors and carbon emissions: change analysis

In our baseline estimations, we perform levels analysis. In this subsection, we perform changes analysis. We do so to examine whether changes in institutional investors impact the changes in carbon emission. Changes analysis captures the effect of changes in independent variables on a dependent variable, which helps reduce shortcomings in levels analysis (Ham and Koharki, 2016). To this end, we re-define carbon emissions as a yearly percentage change in carbon emissions and all other variables are defined to reflect the percentage changes. We present the results of the changes analysis in Appendix Table A7. Our results show that changes in institutional investors help reduce changes in carbon emissions. Overall, this result is consistent with our main result and implies robust evidence that institutional investors contribute to reducing the carbon emissions of a firm.

7. Channel analysis

7.1. Institutional investors and carbon emissions: Energy consumption channel

In this section, we examine if the energy consumption of firms is a channel through which institutional investors may affect carbon emissions. Prior literature (e.g., Paramati et al., 2017) argues that higher

[12] In our un-reported results, we find consistent results using direct and indirect emissions scaled by sales revenue, respectively.

[13] We also estimate the impact of institutional investors on direct and indirect carbon emissions for each sector. Our un-tabulated results are qualitatively similar with Appendix Table 6.

Table 9
Institutional investors and carbon emissions: Channel Analysis.

	(1)	(2)	(3)	(1)	(2)	(3)
Panel A: The impact of institutional investors on energy use (Dep. Var.: energy use)						
Total IO	**−0.8137*****					
	(−4.13)					
Independent IO		**−0.4676****				
		(−2.22)				
Grey IO			**0.7619**			
			(0.59)			
Monitoring IO				**−0.0551*****		
				(−0.3.82)		
Long-term IO					**−0.0680***	
					(−1.88)	
Short-term IO						**−0.5226**
						(−0.86)
Sales growth	0.0025***	0.0021***	0.0020**	0.0021**	0.0027***	0.0020*
	(3.15)	(2.61)	(2.53)	(2.55)	(3.28)	(1.92)
Firm size	0.4760***	0.4500***	0.4826***	0.4788***	0.4793***	0.4966***
	(8.35)	(7.71)	(8.49)	(8.43)	(8.44)	(7.01)
Capital expenditure	0.1421***	0.0227	0.0244	0.0241	0.1469***	−0.0161
	(4.48)	(0.67)	(0.72)	(0.71)	(4.72)	(−0.37)
Leverage	−0.0429	−0.1825	−0.1569	−0.1411	0.0626	−0.2766
	(−0.21)	(−0.90)	(−0.78)	(−0.69)	(0.31)	(−1.11)
R & D intensity	0.0061*	0.0278***	0.0276***	0.0283***	0.0349***	0.0091
	(1.71)	(2.66)	(2.64)	(2.69)	(3.31)	(0.60)
ROA	−0.0083***	−0.0067**	−0.0067**	−0.0068**	−0.0092***	−0.0040
	(−3.07)	(−2.51)	(−2.51)	(−2.53)	(−3.44)	(−1.21)
Cash holdings	0.0172	0.0176	0.0151	0.0161	0.1023***	0.0195
	(0.65)	(0.75)	(0.64)	(0.69)	(4.78)	(0.68)
Constant	15.832***	7.8562***	7.3634***	7.3983***	14.2154***	7.4554***
R-squared	0.1178	0.047	0.046	0.046	0.025	0.043
F-statistics	11.68***	20.16***	19.56***	19.61***	11.91***	12.46***
Year fixed effects	Y	Y	Y	Y	Y	Y
Firm fixed effects	Y	Y	Y	Y	Y	Y
Panel B: The impact of institutional investors on carbon emissions controlling for energy use (Dep. Var.: carbon emissions)						
Total IO	**−0.3099*****					
	(−2.58)					
Independent IO		**−0.3188****				
		(−2.55)				
Grey IO			**−0.9447**			
			(−1.15)			
Monitoring IO				**−0.2120*****		
				(−5.78)		
Long-term IO					**−0.0782****	
					(−2.53)	
Short-term IO						**−0.0617**
						(−0.99)
Energy use	**0.1778*****	0.1593***	0.1596***	0.1584***		0.1240***
	(15.62)	(13.98)	(14.01)	(13.98)	0.1738***	(11.58)
Sales growth	0.0003	−0.0003	−0.0003	−0.0003	(14.99)	−0.0004
	(0.68)	(−0.60)	(−0.63)	(−0.57)	0.0003	(−0.88)
Firm size	0.3364***	0.3317***	0.3372***	0.3390***	(0.69)	0.2966***
	(8.24)	(8.44)	(8.79)	(8.88)	0.4793***	(7.88)
Capital expenditure	0.0432**	−0.0198	−0.0199	−0.0198	(8.44)	−0.0141
	(2.18)	(−0.96)	(−0.96)	(−0.96)	0.0588***	(−0.67)
Leverage	−0.0316	−0.1266	−0.1282	−0.0395	(2.91)	0.0051
	(−0.26)	(−1.05)	(−1.07)	(−0.33)	0.0049	(0.04)
R & D intensity	0.0591**	0.0239***	0.0239***	0.0268***	(0.04)	0.0223***
	(2.25)	(3.92)	(3.92)	(4.41)	0.0278***	(3.33)
ROA	−0.0013	−0.0007	−0.0008	−0.0007	(4.25)	−0.0013
	(−0.83)	(−0.45)	(−0.48)	(−0.44)	−0.0020	(−0.92)
Cash holdings	0.0391***	−0.0018	−0.0016	0.0015	(−1.22)	−0.0008
	(2.84)	(−0.12)	(−0.11)	(0.10)	0.0403***	(−0.06)
Constant	10.84***	5.4605***	5.3696***	5.2416	(2.82)	6.5959***
R-squared	0.5829	0.118	0.118	0.128	0.094	0.125
F-statistics	41.37***	43.34***	43.45***	(8.73) ***	(35.65) ***	31.89 ***
Year fixed effects	Y	Y	Y	Y	Y	Y
Firm fixed effects	Y	Y	Y	Y	Y	Y
Observations	10,101	10,101	10,101	10,101	10,101	10,101

***, ** and * indicate statistical significance at the 1%, 5% and 10% levels, respectively; and t-statistics are reported in parentheses.

non-renewable energy consumption increases carbon emissions. Guided by the prior studies in the literature (e.g., Cheung, 2016: Balachandran and Nguyen, 2018), we conduct the channel analysis first, by examining whether the energy consumption of firms is reduced by larger ownership by institutional investors and then investigating the impact of institutional ownership on carbon emissions after controlling energy consumption.

Our results in Panel A of Table 9 demonstrate that the coefficient of the measure of total institutional ownership is negative and significant at the 1% level, with an estimate of −0.814, suggesting that an increase in institutional ownership reduces energy consumption. Panel B of Table 9 shows that the energy consumption coefficient is positive and is statistically significant at the 1% level, which suggests that firms with higher energy consumption have a higher carbon emissions. The coefficient of institutional ownership is also significantly negative, with an estimate of −0.309. This result suggests that carbon emissions are lower for firms with larger ownership by institutional investors, even after controlling for energy consumption.

We re-do the above estimations using alternative measures of institutional ownership as reported in sections 3.2–3.4. The results remain valid. These robust findings support the notion that institutional investors reduce energy consumption, which in turn reduces carbon emissions.[14]

7.2. *Institutional investors and carbon emissions: Shareholder's activism*

This section explores a proximal monitoring channel through which institutional investors affect carbon emissions. Institutional investors use the 'exit' or 'voice' mechanism to monitor or influence the firms they invest in (McCahery et al., 2016). The 'voice' mechanism is more plausible than the 'exit' due to their significant and long-term investments. The literature shows that 'voice' is an important mechanism through which institutional investors push firms to achieve better performance, including CSR activities (Chen et al., 2020). Our study finds that institutional investors contribute to reducing carbon emissions. Now, the question is how institutional investors monitor a firm's carbon abatement activities of a firm? To answer this question, we use carbon emissions-related shareholder proposals or voices as a channel through which institutional investors can influence a firm's decisions or policies on carbon emissions. The idea is that if institutional investors exert effort to reduce their portfolio firms' carbon emissions, we should observe that higher ownership and monitoring intensity by institutions would increase carbon emissions-related proposals. The motivation to use the carbon emissions proposal of shareholders as a potential channel derives from the fact that institutional investors consider socially irresponsible behaviour as a vital point of shareholder activism (McCahery et al., 2016). It is also evident in the literature that the use of 'voice' or the mere threat of voting can increase shareholders' influence over firm policies.

To examine this potential channel, we use carbon emissions-related shareholder proposals data from the ISS RiskMetrics to examine this potential channel. Shareholder proposals are official written requests submitted to listed firms under Rule 14a-8 of US SEC. Any shareholder holding shares valued at a minimum of $2000 for at least one year is entitled to file a proposal for consideration. However, submission does not guarantee that the proposal will be included in the proxy statement and voted on at the AGM. We approach carbon emissions-related shareholder proposals as a public, collective and organized action aimed at triggering shareholders' concerns to curb higher emissions, consistent with our theoretical argument. Following prior literature (Chen et al., 2020; Hadani et al., 2019; Neubaum and Zahra, 2006), we empirically test this channel by multiplying the total institutional investors holdings with the measure of shareholders' activism related to carbon emissions. More specifically, we use the following model, which is an extended version of our base model (1):

$$CEs_{it} = \alpha + \beta_1 IO_{it-1} + \beta_2 CEP + \boldsymbol{\beta_3 IO_{it-1} \times CEP} + \gamma Z_{it-1} + \epsilon_{it} \tag{9}$$

Our variable of interest is the interaction between total institutional investors holdings and carbon emissions proposals ($IO_{it-1} \times CEP$). The coefficient, β_3 in our model (9) explains the interaction effect of institutional investors holdings and carbon emissions proposals on carbon emissions. Our results in Table 10 show that the interaction term (Total IO × Carbon emissions proposal) has a significant and negative effect on carbon emissions. This result implies that institutional investors use carbon emissions proposals to influence firms' strategic decisions on carbon emissions abatement. To this end, our study supports prior studies (e.g., Chen et al., 2020) that show that institutional investors' proposal is a monitoring channel to influence firm performance. However, our study adds to this strand of literature that shareholder proposals also serve as a monitoring mechanism to reduce carbon emissions.

Table 10
Institutional investors and carbon emissions: Shareholder's activism.

	TCE	DCE	INCE
	(1)	(2)	(3)
Total IO	−0.3366***	−0.1092	−0.5024***
	(−4.20)	(−0.75)	(−2.87)
Carbon emissions proposal	0.0224	0.0826	0.1674
	(0.33)	(0.89)	(1.29)
Total IO × Carbon emissions proposal	**−0.2201****	**−0.4751***	**−0.5541***
	(−1.96)	**(−1.82)**	**(−1.94)**
Sales growth	0.0003***	0.0009***	0.0006**
	(3.77)	(4.22)	(2.42)
Firms size	0.6571***	0.4614***	0.6229***
	(29.36)	(12.25)	(14.09)
Capital expenditure	0.1543***	0.1391***	0.0822***
	(13.99)	(7.32)	(3.64)
Leverage	0.0524	0.0250	0.0169
	(0.76)	(0.21)	(0.12)
R & D intensity	0.0103**	0.0124**	0.0173**
	(2.35)	(2.17)	(2.48)
ROA	−0.0007	−0.0038**	−0.0014
	(−0.82)	(−2.47)	(−0.74)
Cash holdings	0.0867***	0.0599***	0.0809***
	(9.88)	(4.81)	(5.40)
Constant	11.1345***	12.0890***	11.4981***
	(18.56)	(60.47)	(46.01)
Year fixed effects	Y	Y	Y
Firm fixed effects	Y	Y	Y
R-squared	0.048	0.044	0.034
F-statistics	17.02***	6.29***	4.53***
Observations	10,087	4035	3816

***, ** and * indicate statistical significance at the 1%, 5% and 10% levels, respectively; and t-statistics are reported in parentheses.

8. Do the effects of institutional investors on carbon emissions have value relevance?

Our prior results show that institutional investors contribute to reducing carbon emissions. A usual follow-up question is, "Do the effects of institutional investors on carbon emissions have value relevance?" To provide an answer to this question, we test the value relevance of carbon emissions and their interaction with institutional ownership using a modified form of Ohlson's (1995) valuation model, relating the market value of a firm's common equity to the book value of common equity and earnings. Prior studies in the carbon valuation literature commonly use valuation models based on Ohlson (Chapple et al., 2013; Clarkson et al., 2015; Matsumura et al., 2014; Griffin et al., 2017). Our value implications model is defined as:

[14] We also perform this channel analysis using direct and indirect carbon emissions. The results remain unchanged.

Table 11
Value relevance of institutional investors influence on carbon emissions.

	Panel A		Panel B		Panel C		Panel D	
	(1)	(2)	(1)	(2)	(1)	(2)	(1)	(2)
Carbon emissions	−3.8142***	−3.5182***	−3.8095***	−3.4683***	−3.8044***	−3.2288***	−3.5399***	−3.2288***
	(−3.82)	(−3.01)	(−3.82)	(−2.99)	(−3.81)	(−3.59)	(−4.03)	(−3.59)
Total IO	−1.7953							
	(−0.59)							
Carbon emissions × Total IO		−0.3627						
		(−0.57)						
Monitoring IO			**3.5710****					
			(1.98)					
Carbon emissions × Monitoring IO				**0.4730****				
				(1.99)				
Long-term IO					2.6468			
					(0.82)			
Carbon emissions × Long-term IO						**−0.5126****		
						(−2.33)		
Short-term IO							**6.7197****	
							(2.44)	
Carbon emissions × Short-term IO								**0.5126****
								(2.33)
Book value of equity	0.6216***	0.7241***	0.6259***	0.7231***	0.6231***	1.0502***	0.6272***	1.0502***
	(6.40)	(6.88)	(6.45)	(6.87)	(6.42)	(12.09)	(7.72)	(12.09)
Income before extraordinary items	0.5165***	0.3437***	0.5189***	0.3480***	0.5129***	0.1664	0.5910***	0.1664
	(4.33)	(2.82)	(4.35)	(2.85)	(4.30)	(1.53)	(5.32)	(1.53)
Constant	79.006***	74.830***	79.111***	74.227***	78.896***	64.538***	74.068***	64.538***
R-squared	0.072	0.070	0.072	0.071	0.072	0.130	0.084	0.130
F-statistics	32.47***	27.30***	32.75***	27.82***	32.55***	62.02***	45.59***	62.02***
Year fixed effects	Y	Y	Y	Y	Y	Y	Y	Y
Firm fixed effects	Y	Y	Y	Y	Y	Y	Y	Y
Observations	10,101	10,101	10,101	10,101	10,101	10,101	10,101	10,101

***, ** and * indicate statistical significance at the 1%, 5% and 10% levels, respectively; and t-statistics are reported in parentheses.

$$MV_{it} = \gamma_0 + \gamma_1 CEs_{it} + \gamma_2 IO_{it} + \gamma_3 CEs_{it} \times IO_{it} + \gamma_4 BV_{it} + \gamma_5 IBEI_{it} + \epsilon_{it} \quad (10)$$

where MV_{it} is total market value (capitalization) of equity at the end of year t; CEs_{it} is all the three measures of carbon emissions (total, direct and indirect);IO_{it} is the ownership of institutional investors; BV is the total common equity of a firm; *IBEI* is income before extraordinary items. The total number of common shares outstanding is used a scale variable to define market value, book value, and earnings. Our coefficient of interest is γ_3 for the interaction term $CEs_{it} \times IO_{it}$, that captures the valuation effect of carbon emissions in firms with institutional ownership. This model differs from our predecessors in that we use institutional ownership, carbon emissions, and their interaction with intuitional ownership as factors of valuation. In the interaction term, we use alternative proxies of institutional ownership, including ownership of monitoring institutional investors and long-term and short-term institutional ownership.

Panels A—D of Table 11 indicate that high carbon emissions reduce firm value. The impact of total and long-term institutional owners is statistically insignificant, but the firm value increases with high-monitoring institutional investors and short-term institutional investors. This finding is consistent with the evidence presented in Yan and Zhang (2007) that short-term institutions' trading forecasts stock returns and increases future earnings surprises, while the opposite holds true for long-term investors. Regarding the effect of our variable of interest, the results in Panels A and C demonstrate that the coefficient of the interaction term is statistically insignificant between carbon emissions and total institutional ownership (*Carbon emissions* × *Total IO*) but negative between carbon emissions and long-term institutional ownership (*Carbon emissions*× *Long-term IO*). Contrarily, the coefficient of the interaction term between carbon emissions and monitoring institutional ownership (*Carbon emissions*× *Monitoring IO*) and between carbon emissions and short-term institutional ownership (*Carbon emissions* × *Short-term IO*) is positive and statistically significant. These findings together suggest that the interactive impact of carbon emissions and monitoring and carbon emissions and short-term institutional investors on firm value outweigh the negative direct effect of high carbon emissions on the value of the firm. Overall, this result, coupled with the preceding results, implies that the benefit, particularly for monitoring investors in reducing carbon emissions, is higher firm value. This result proves that it is worthy to examine the carbon emissions effect of ownership by monitoring, short-term and long-term institutional investors instead of examining ownership proxy only by total institutional investors, as the role of all institutional investors is not equally valued by market participants.

9. Conclusion

This study adds to the literature on the role of institutional investors in corporate performance by providing novel empirical evidence that not all types of institutional investors equally promote firm-level carbon reduction. Our main results are as follows. First, our findings suggest that there is a positive impact of aggregate institutional ownership on the reduction of carbon emissions. Second, the influence of institutional investors on carbon emission abatement is mainly attributable to independent institutional investors rather than grey institutional investors. Investment companies and investment advisors have a strong contribution compared to all other types of institutional investors (e.g., banks and insurance companies). Third, long-term institutional investors have greater influence in reducing carbon emissions than their short-term peers. Fourth, our findings reveal that monitoring institutional investors reduce carbon emissions significantly. These findings are robust to alternative econometric specifications and alternative measures of carbon emissions. Using a quasi-natural experiment and difference-in-differences approach to address potential endogeneity concerns, we find our results to be robust. Finally, our results confirm that institutional investors reduce carbon emissions by minimizing energy consumption. We also find that shareholder activism is a monitoring mechanism through which institutional investors influence management to achieve better carbon performance.

Overall, institutional investors, particularly independent, long-term, and monitoring, play a decisive role in firm-level carbon emissions reduction. This finding has important managerial and policy implications. To abate carbon emissions or reduce their contribution to climate change, firms might focus more on having independent, long-term and monitoring institutional investors in their ownership profiles. This can be ensured by implementing conducive policies and strategies on the firm and national level that attract such institutional investors.

We limited the focus of this study to carbon emissions, as these are regarded as the important inputs for climate change. Future research may extend our study by investigating whether and how institutional investors affect other climate change indicators. Moreover, in this study, our sample period covered from 2007 to 2017. Future researchers may extend this sample period when more data on carbon disclosure becomes available. The context of our study could also be replicated in other than U.S. markets with distinct cultural backgrounds and institutional settings.

Declaration of Competing Interest

There is no conflict of interest and declarations of interest.

Acknowledgements

We thank Eliezer M. Fich, Avanidhar (Subra) Subrahmanyam, Lilian Ng, Iftekhar Hasan, Anh L. Tran, Robert Faff, Huu Nhan. Duong for helpful comments on the earlier version of this paper. We also acknowledge helpful comments from the participants at the Finance of Climate Change conference, 16 December 2019, Paris, France; BAFA Corporate Governance SIG conference, 18 December 2019, The University of Sheffield, UK; Research seminar at De Montfort University, Leicester, UK.

Appendix A. Appendix

Table A1 Variable definitions.

Variable names	Measures
Panel A: Dependent variables	
Total carbon emission (TCE)	Total carbon emissions (in tonnes)
Direct carbon emission (DCE)	Total direct carbon emissions (in tonnes)
Indirect carbon emission (INCE)	Total indirect carbon emissions (in tonnes)
Nitrogen Oxide emissions (Nox)	Total Nitrogen Oxide emissions (in tonnes)
Panel B: Independent variables (variables of interest)	
Total institutional ownership (Total IO)	Total institutional ownership in percentage of market capitalization
Independent institutional ownership (Independent IO)	Institutional ownership ratio (independent institutions) in percentage of market capitalization
Grey institutional ownership (Grey IO)	Institutional ownership ratio (grey institutions) in percentage of market capitalization
Long-term institutional ownership (Long-term IO)	Institutional investors with their positions unchanged for a considerable length of time as per the Churn rate
Short-term institutional ownership (Short-term IO)	Institutional investors with frequent shares trading as per the Churn rate
Monitoring institutional ownership (Monitoring IO)	Institutional investors whose holding value in the firm is in the top decile of their portfolio as devised by Fich et al. (2015)
Domestic institutional ownership (Domestic IO)	Total domestic institutional ownership ratio in percentage of market capitalization
Foreign institutional ownership (Foreign IO)	Total foreign institutional ownership ratio in percentage of market capitalization
Panel C: Control variables	
Sales Growth	Measured as (Net sales in year t minus Net sales in year t-1 divided by Net sales in year t-1
Firm Size	Measured as the natural log of total assets
Capital expenditures	Measured as the total capital expenditures for the year
Leverage	Measured as the total of long term and short-term debt divided by total assets
R&D intensity	Measured as the ratio of R&D expenses to Net Sales. Set to zero if R&D expense is missing.
Return on assets (ROA)	Return on assets
Cash holdings	Measured as the total cash and cash equivalent held in the year
Total energy consumed by the firm	Measured in GwH as the total of the direct and indirect energy consumed by the firm
Market value to common shares outstanding (MV)	Ratio of the market value per share to common stock outstanding
Book value to common shares outstanding (BV)	Ratio of the book value per share to common stock outstanding
Extraordinary earnings per share (ExEPS)	Total extraordinary earnings by common stock outstanding

Table A3 Institutional investors and carbon emissions: Alternative measure of carbon emissions.

	(1)	(2)	(3)	(4)	(5)	(6)
	TCE	TCE	TCE	TCE	TCE	TCE
Total IO	−0.0174***					
	(−8.09)					
Independent IO		−0.0178***				
		(−7.84)				
Grey IO			−0.0011			
			(−0.04)			
Monitoring IO				−0.0294***		
				(−13.42)		

(continued on next page)

(*continued*)

	(1)	(2)	(3)	(4)	(5)	(6)
	TCE	TCE	TCE	TCE	TCE	TCE
Long-term IO					−0.0030	
					(−1.82)	
Short-term IO						0.0053**
						(2.07)
Sales growth	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000
	(0.33)	(0.28)	(0.50)	(0.26)	(0.60)	(0.21)
Firm size	0.0156***	0.0156***	0.0154***	0.0154***	0.0154***	0.0162***
	(23.07)	(23.05)	(22.73)	(22.93)	(22.73)	(20.73)
Capital expenditure	0.0695***	0.0698***	0.0720***	0.0676***	0.0739***	0.0816***
	(15.49)	(15.56)	(16.07)	(15.18)	(16.53)	(16.46)
Leverage	−0.0001	−0.0001	−0.0001	−0.0002	−0.0000	−0.0004
	(−0.63)	(−0.60)	(−0.42)	(−0.99)	(−0.18)	(−1.48)
R & D intensity	−0.0000	−0.0001	−0.0000	−0.0001	−0.0001	0.0000
	(−0.45)	(−0.53)	(−0.45)	(−1.15)	(−0.51)	(0.05)
ROA	0.0135***	0.0144***	0.0148***	0.0136***	0.0144***	0.0124***
	(14.57)	(15.66)	(16.04)	(14.86)	(15.65)	(11.68)
Cash holdings	−0.0131***	−0.0131***	−0.0130***	−0.0133***	−0.0127***	−0.0114***
	(−17.82)	(−17.76)	(−17.65)	(−18.23)	(−17.31)	(−13.55)
Constant	0.4409***	0.4333***	0.4282***	0.4497***	0.4331***	0.5093***
R-squared	0.561	0.561	0.559	0.566	0.558	0.576
F-statistics	251.66	251.45	249.87	256.72	248.73	209.66
Observations	10,083	10,085	10,085	10,085	10,085	10,085

***, ** and * indicate statistical significance at the 1%, 5% and 10% levels, respectively; and t-statistics are reported in parentheses. TCE is the total carbon emissions.

Table A4 Institutional investors and carbon emissions by firm size.

	Panel A: Large Firms			Panel B: Small Firms		
	TCE	DCE	INCE	TCE	DCE	INCE
	(1)	(2)	(3)	(4)	(5)	(6)
Total IO	−0.3179***	−0.2272***	−0.3786***	−0.2467***	−0.6733*	−0.5414*
	(−7.04)	(−2.89)	(−6.30)	(−3.65)	(−1.70)	(−1.83)
Sales growth	−0.0009***	−0.0002	−0.0011*	−0.0004	−0.0152	−0.0078
	(−2.81)	(−0.23)	(−1.85)	(−1.59)	(−1.65)	(−1.06)
Firms size	0.8170***	0.9046***	0.7213***	0.8867***	1.1524***	0.8155***
	(40.29)	(24.61)	(26.50)	(20.39)	(3.81)	(3.80)
Capital expenditure	0.3590***	0.6589***	0.3619***	0.3375***	0.8176***	0.2159
	(25.58)	(21.81)	(15.82)	(16.46)	(5.14)	(1.63)
Leverage	0.7383***	−0.0072	0.0633	1.0386***	0.9258	−0.1666
	(6.95)	(−0.03)	(0.40)	(9.48)	(0.84)	(−0.21)
R & D intensity	0.0414***	−0.0163**	0.0307***	−0.0092	0.0301	0.0690**
	(9.19)	(−2.25)	(5.54)	(−1.38)	(0.81)	(2.35)
ROA	0.0015	−0.0025	0.0105***	0.0089***	−0.0001	0.0025
	(0.55)	(−0.54)	(2.92)	(5.23)	(−0.01)	(0.26)
Cash holdings	0.3045***	0.2784***	0.2906***	0.0275	−0.1777	−0.2151**
	(28.48)	(13.56)	(18.76)	(1.29)	(−1.52)	(−2.07)
Constant	4.6230***	9.0300***	8.0258***	10.3706***	18.0852***	2.4888
	(2.62)	(15.64)	(16.68)	(25.97)	(8.16)	(0.85)
Year fixed effects	Yes	Yes	Yes	Yes	Yes	Yes
Industry fixed effects	Yes	Yes	Yes	Yes	Yes	Yes
R-squared	0.577	0.611	0.424	0.495	0.665	0.621
F-statistics	213.18***	123.48***	54.68***	53.08***	8.46***	6.96***
Observations	7718	3829	3610	2369	206	206

***, ** and * indicate statistical significance at the 1%, 5% and 10% levels, respectively.

and t-statistics are reported in parentheses.

Table A5 Institutional investors and carbon emissions: controlling for industry effects.

	TCE	DCE	INCE
	(1)	(2)	(3)
Panel A: Controlling for industry fixed effects			
Total IO	−0.3662***	−0.2341***	−0.3742***
	(−9.34)	(−3.03)	(−6.33)
Other controls	Yes	Yes	Yes
Year control	Yes	Yes	Yes
Industry control	Yes	Yes	Yes
R-squared	0.598	0.610	0.440
F-statistics	299.08***	129.65***	61.78***
Observations	10,087	4035	3816

(*continued on next page*)

(*continued*)

	TCE	DCE	INCE
	(1)	(2)	(3)
Panel B: Controlling for industry by state fixed effects			
Total IO	−0.3684***	−0.2956***	−0.6808***
	(−8.09)	(−2.92)	(−8.97)
Other controls	Yes	Yes	Yes
Year control	Yes	Yes	Yes
Industry by state fixed effects	Yes	Yes	Yes
R-squared	0.623	0.629	0.471
F-statistics	99.08***	26.52***	34.39***
Observations	9601	3840	3623
Panel C: Controlling for industry by time trend fixed effects			
Total IO	−0.3662***	−0.2341***	−0.3742***
	(−9.34)	(−3.03)	(−6.33)
Other controls	Yes	Yes	Yes
Industry by time trend fixed effects	Yes	Yes	Yes
R-squared	0.623	0.629	0.471
F-statistics	99.08***	26.52***	34.39***
Observations	9601	3840	3623

***, ** and * indicate statistical significance at the 1%, 5% and 10% levels, respectively; and t-statistics are reported in parentheses.

Table A6 Institutional investors and carbon emissions: GICS industry sector wise results.

	Energy (10)	Materials (15)	Industrials (20)	Consumer Discretionary (25)	Consumer Staples (30)	Health care (35)	Financials (40)	Information Technology (45)	Communication Services (50)	Utilities (55)	Real Estates (60)	Excluding GICS industry sector 25
Total IO	−0.2305***	−1.0158***	−0.2224*	−0.4218***	−0.1500	−0.5230**	−0.2888***	−0.2162**	−2.5341***	−0.3749***	−0.6583***	−0.3941***
	(−2.91)	(−9.57)	(−1.75)	(−4.70)	(−1.34)	(−2.43)	(−2.77)	(−2.18)	(−6.85)	(−3.30)	(−9.43)	(−4.80)
Other controls	Y	Y	Y	Y	Y	Y	Y	Y	Y	Y	Y	Y
R-squared	0.802	0.446	0.518	0.427	0.448	0.454	0.371	0.307	0.867	0.411	0.633	0.064
F-statistics	190.76***	69.18	30.98	104.98	39.89	20.28	62.75	26.3	17.08	59.64	155.63	18.70***
Observations	914	1655	538	2558	902	458	1938	1390	70	1557	996	7529

***, ** and * indicate statistical significance at the 1%, 5% and 10% levels, respectively; and t-statistics are reported in parentheses. In all empirical models we control for year and firm fixed effects. GIC industry sector number is in the parenthesis followed by the sector name.

Table A7 Institutional investors and carbon emissions: change analysis.

	ΔTCE	Δ DCE	Δ INCE
	(1)	(2)	(3)
Δ Total IO	−0.1979**	−0.7057	−0.5078**
	(−2.01)	(−0.10)	(−2.15)
Δ Sales growth	0.0112***	0.0154*	0.0161***
	(15.57)	(1.80)	(7.59)
Δ Firms size	−0.0793*	−0.4257	−0.1569
	(−1.86)	(−0.26)	(−1.42)
Δ Capital expenditure	0.0463	0.2399	0.0429
	(1.50)	(0.27)	(0.49)
Δ Leverage	−0.1706	0.2322	−0.6007
	(−0.83)	(0.05)	(−0.99)
Δ R & D intensity	−0.0038	0.0394	0.0004
	(−0.40)	(0.16)	(0.02)
Δ ROA	−0.0044	−0.0400	0.0138
	(−0.92)	(−0.64)	(1.04)
Δ Cash holdings	0.0083	0.3452	0.0460
	(0.25)	(0.63)	(0.54)
Constant	0.1413	3.4433	6.9930***
	(0.03)	(0.13)	(3.58)
Year fixed effects	Yes	Yes	Yes
Industry fixed effects	Yes	Yes	Yes
R-squared	0.036	0.05	0.041
F-statistics	6.64***	0.61***	2.82***
Observations	8591	3349	3114

***, ** and * indicate statistical significance at the 1%, 5% and 10% levels, respectively; and t-statistics are reported in parentheses.

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