# Are lead independent directors greener? Evidence from climate change commitment and ESG performance

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# Are lead independent directors greener? Evidence from climate change commitment and ESG performance

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# Are lead independent directors greener? Evidence from climate change commitment and ESG performance


## Abstract

### Purpose
This paper sheds light on how appointing a lead independent director (LIDIR) affects a firm's commitment to climate change and to what extent environmental, social and governance (ESG) performance is affected by a firm's commitment to climate change in the presence of a LIDIR.

### Design/methodology/approach
The authors utilise ordinary least squares (OLS) and a sample of 12,236 firm-year observations in the United States (US) over the 2002-2019 period to test the predictions. The authors also apply alternative research designs such as propensity score matching, Heckman two-step and instrumental variable techniques to address endogeneity concerns.

### Findings
The authors find that a LIDIR representation on the board is positively associated with a firm's commitment to climate change. The authors also find that the association between a LIDIR representation on the board and a firm's commitment to climate change is more pronounced in firms with a combined Chief Executive Officer (CEO) and board chair positions than firms with both positions separated. Additional analysis suggests that increased commitment to climate change in the presence of a LIDIR improves ESG performance.

### Originality/value
While the effect of a LIDIR on firm financial outcomes has received much attention, there is lack of empirical evidence on whether lead independent directors are greener. The authors provide new and important contribution to the literature by investigating the relationship between a LIDIR representation on the board and non-financial outcomes from the perspective of climate change commitment and ESG performance. The findings may be informative to policymakers seeking to deal with climate change impacts on society to encourage the appointment of a LIDIR.



**Keywords**: Lead independent directors; climate change commitment; ESG performance

## 1. Introduction

With the heightened interest in the board leadership independence, and pressure from corporate watchdogs and legislators towards the separation of the Chief Executive Officer (CEO) and the board chair positions (hereafter CEO chair), firms are under pressure from regulators to appoint a lead independent director (LIDIR) as a power-balancing mechanism to avoid role separation[1]. The importance of a LIDIR representation on the board goes beyond improving firm financial outcomes (e.g., Krause *et al*., 2017; Hsu *et al*., 2024). For example, Calpers, the US's biggest public pension fund and other investors threatened to vote against the re-election of the CEO chair (i.e., Darren Wood) and the LIDIR (i.e., Jay Hooley) following a climate lawsuit by ExxonMobil. While the Security and Exchange Commission (SEC) allows climate change-related proposals to be voted on by shareholders, ExxonMobil were not happy about the climate-focused investors repeated proposals that aim at influencing environmental, social and governance (ESG) issues[2]. The investors protest is of significance because not only do they focus on the re-election of the CEO chair but also the role played by the LIDIR in the climate lawsuit. Nevertheless, lead independent directors, as one of the most important individuals in the board leadership structure, are leading the charge for the implementation of climate change policies to achieve carbon neutrality by 2050 and decarbonisation of global economies[3]. As an example, Dame Amanda Blanc, a LIDIR at the British Petroleum (BP) plc has been actively involved and committed to advancing climate-related initiatives within and beyond BP plc[4].

[1]It is worth noting that the appointment of a LIDIR was first introduced in the early 2000s by regulators in the United States (US) to prevent the separation of CEO and the board chair positions following the concerns expressed by corporate watchdogs and legislators (Dalton and Dalton, 2005; Krause *et al*., 2017). It has also gained wider interest from the European countries where corporate governance environment is different. For example, France, Germany, Italy, Switzerland, and the United Kingdom (UK) regulators have implemented a LIDIR policy (Davies and Hopt, 2013; Allianz Global Investors, 2022).

[2] https://www.ft.com/content/4c33cdcf-3914-4dea-829b-cdb6e5c223cd

[3]https://www.miningweekly.com/article/tharisa-makes-lead-independent-director-board-committee-changes-2021-09-21

[4]https://www.bp.com/en/global/corporate/who-we-are/board-and-executive-management/the-board/amanda-blanc.html

According to corporate governance observers, the LIDIR is a credible alternative when the CEO and the board chair positions are consolidated (National Association of Corporate Directors, 2004), provides a power-balancing mechanism on the board (Krause *et al*., 2017; The Institute of Directors, 2018), and addresses investors' concerns when they are unable to agree with the executives or the board chair (Owusu *et al*., 2023). Unlike other independent directors, a LIDIR is assigned specific roles, including liaising between the CEO chair and independent directors as well as majority shareholders, calling and overseeing meetings of outside directors, reviewing and approving meeting agendas, and evaluating the performance of management and other directors (Lamoreaux *et al*., 2019; Rajkovic, 2020). These specific roles show that a LIDIR is mandated to challenge a powerful CEO on decisions not in the best interest of shareholders and the wider stakeholders.

Motivated by the emerging interest surrounding the role of a LIDIR in climate change issues, we investigate how appointing a LIDIR may affect a firm's commitment to climate change. More specifically, we investigate whether a LIDIR representation on the board enhances a firm's commitment to climate in response to investors demand and other stakeholder pressures. Our aim to investigate the relationship between a LIDIR and a firm's commitment to climate change is motivated by multiple reasons. First, previous research has widely focused on the relationship between a LIDIR representation on the board and various aspects of firm financial outcomes (e.g., Krause *et al*., 2017; Lamoreaux *et al*., 2019; Owusu *et al*., 2023; Hsu *et al*., 2024) with little attention to non-financial outcomes. We expand this stream of research to investigate how a LIDIR representation on the board drives a firm's commitment to climate change. So far, it is not empirically clear whether lead independent directors are greener, and this study provides fresh answers to how a LIDIR enhances a firm's commitment to climate change. By doing so, we respond to the recent calls for more research into the role of a LIDIR in other firm outcomes (Rajkovic, 2020).

Second, previous research has always not explored the effectiveness of a LIDIR in firms with a CEO chair compared with firms with a non-CEO chair. Nevertheless, firms with a CEO chair may be more scrutinised by a LIDIR than other firms with a non-CEO chair, as board and manager conflicts may be more visible in the former board leadership structure. This study seeks to investigate how a LIDIR may affect climate change commitment in firms with these two distinctive board leadership structures. By doing so, we shift from previous research that focuses on the impact of lead independent directors on firm financial outcomes. Instead, we investigate the role of lead independent directors in fostering climate change commitment within firms, differentiating between those with a CEO chair and those with a non-CEO chair. Third, as in the ExxonMobil case above, investors interest in ESG issues has spectacularly increased, and our aim is to understand how a firm's commitment to climate change in the presence of a LIDIR drives better ESG performance. So far, no study has explored how a LIDIR representation on the board affects a firm's commitment to climate change and whether this effect leads to a strong ESG performance. We fill this gap in the literature by investigating how ESG performance is affected by a firm's commitment to climate change in the presence of a LIDIR.

There are several reasons why a LIDIR representation on the board can enhance a firm's commitment to climate change. We argue, first, that in common with the compromise board leadership structure theory (Krause *et al*., 2017), the presence of a LIDIR can balance the unity of command and independent monitoring through strong leadership and effective oversight, particularly in the context of climate change. Unlike other independent directors, their unique position in the board leadership structure and the assigned specific board leadership roles allow them to challenge a powerful CEO to adopt more ambitious climate actions and integrate these into the overall business strategy, thereby enhancing a firm's commitment to climate change. Second, climate change poses a significant risk to the planet

(Albitar *et al*., 2023), and climate inaction could lead to severe fines and liabilities (Walls *et al*., 2012; Matsumura *et al*., 2014) as well as media scrutiny that can lead to stock market shocks (Xu *et al*., 2016). In their effort to enhance board leadership independence, lead independent directors are likely to ensure boards are both decisive and accountable, facilitating better decision-making in response to climate change challenges. Third, considering that climate-focused investors can put forward climate change-related proposals to be voted on by shareholders, climate inaction can threaten the re-election of lead independent directors and their reputation in the job market, so they are more likely to influence managerial decisions in favour of more commitment to climate change. Based on the preceding arguments, we expect a LIDIR representation on the board to be associated with an increase in a firm's commitment to climate change.

Using a large sample of US listed firms from 2002 to 2019, this study relies on the commitment to climate change composite score suggested by Albitar *et al*. (2023) to empirically test our expectation. We find strong support for our expectation that a LIDIR representation on the board is positively and significantly associated with a firm's commitment to climate change. These results are in common with the compromise board leadership structure theory, in that a LIDIR can use their effective leadership and strong oversight to increase a firm's commitment to climate change. Our results are robust to several sensitivity tests, including alternative measures of a LIDIR, additional control variables, subsample analysis, alternative research designs to address self-selection bias and endogeneity concerns.

In addition, we compare the relationship between a LIDIR representation on the board and climate change commitment in firms with a CEO chair versus firms with a non-CEO chair. We argue that differences in board and manager conflicts and the associated scrutiny between the two groups of firms are likely to result in a stronger impact of a LIDIR on the

commitment to climate change in firms with a CEO chair than in firms with a non-CEO chair. Our findings show significant difference between the two groups of firms regarding the role of lead independent directors in enhancing climate change commitment. It is possible that firms with a CEO chair are under pressure to implement climate change policies, with lead independent directors challenging the powerful CEO chair in these firms to adopt more ambitious climate actions to increase climate change commitment.

Next, we investigate whether a firm's commitment to climate change in the presence of a LIDIR results in a better ESG performance. As pressure from investors towards more commitment to climate change is increasing, lead independent directors may use their unique positions and the assigned specific board leadership roles to influence the implementation of climate change policies, which will ultimately drive ESG performance. In further analyses, we find strong evidence to suggest that when firms commit to the implementation of climate change policies in the presence of a LIDIR, ESG performance will improve.

Our paper makes several new and important contributions to the existing literature. First, we expand previous research on the determinants of corporate commitment to climate change. Unlike Albitar *et al*. (2023) study which focused on the impact of eco-innovation and climate governance on corporate commitment to climate change, we provide strong new evidence of the impact of a LIDIR on a firm's commitment to climate change. We, therefore, contribute to the existing literature by discovering a new determinant of corporate commitment to climate change. Our findings have important implications for policymakers. More specifically, for regulators outside the US jurisdiction, this study provides new insights into how a LIDIR representation on the board addresses climate change issues, which suggests a business case for policymakers seeking to use the board leadership structure to deal with climate change impacts on society to encourage the appointment of a LIDIR.

Second, this paper contributes to the LIDIR literature. Unlike previous studies that have specifically focused on the impact of a LIDIR on firm financial outcomes, such as firm performance (Krause *et al*., 2017; Lamoreaux *et al*., 2019), investment efficiency (Rajkovic, 2020), managerial risk-taking and cost of debt (Owusu *et al*., 2023), and earnings management (Hsu *et al*., 2024), we empirically investigate how a LIDIR may directly influence non-financial outcomes. We contribute to this stream of literature by providing new evidence to suggest that a LIDIR representation on the board increases a firm's commitment to climate change.

Finally, we find that the interaction between a LIDIR and a firm's commitment to climate change increases ESG performance. This novel evidence offers new insights into the relationship between the implementation of climate change policies and ESG performance. While this evidence is new, we also reveal the context by which a firm's ESG performance will improve following the implementation of climate change policies in the presence of a LIDIR. To our knowledge, this is the first study to investigate the role of a LIDIR in enhancing the possible benefit of a firm's commitment to climate change for ESG performance. Our findings show that even though a firm's commitment to climate change has no effect on ESG performance, the rating agencies value a LIDIR representation on the board in enhancing climate change commitment. Thus, a LIDIR representation on the board strengthens the implementation of climate change policies to benefit ESG performance.

The rest of the paper is organised as follows. In section 2, we review the relevant literature to motivate our hypothesis. Section 3 discusses the research design. Section 4 presents the empirical results, while section 5 concludes the study.

## 2. Literature review and hypotheses development

This section reviews the literature on climate change commitment and the impact of a LIDIR representation on corporate outcomes. We draw on the synthesis of this literature to develop our hypotheses.

### *2.1 Literature review on climate change commitment*

Considering that a firm's commitment to climate change reflects its policies that address climate change issues, researchers have explored many aspects. Accordingly, climate change policies are widely implemented to (1) improve energy efficiency, (2) support sustainable development goal (SDG) 13 on climate action, (3) address climate change risks and opportunities, (4) report scope 3 $CO_2$ emissions, and (5) achieve carbon emissions reduction target (Kasidou and Demirel, 2012; Lin and Zhu, 2019; Erdogan *et al*., 2020; Albitar *et al*., 2023). In recent years, the wider stakeholder groups, including investors, communities, media, managers, suppliers, professionals, and governments, have made every effort to motivate firms to commit to climate change initiatives (Borghesi *et al*., 2015; Haque *et al*., 2016; Hollindale *et al*., 2019; Afrifa *et al*., 2020; Karim *et al*., 2021; Krieger and Zipperer, 2022). Indeed, firms seek to commit to climate change by implementing policies that are likely to reduce their footprint (Erdogan *et al*., 2020). As such, additional effort from their board leadership is required to demonstrate genuine commitment to climate change. However, such effort may require a power-balancing mechanism (i.e., the appointment of a LIDIR) at the top of the firm in response to investors demand and other stakeholder pressures on climate change issues.

Previous studies (e.g., Walls *et al*., 2012; Matsumura *et al*., 2014; Haque *et al*., 2016; Xu *et al*., 2016; Krieger and Zipperer, 2022) on corporate commitment to climate change issues has two competing perspectives – climate action and climate inaction. Both perspectives affect corporate commitment to climate change. From the climate action

perspective, a firm is more likely to respond to the growing interest of investors, customers, governments, and regulators on climate change issues, which may lead to increased commitment to implementing climate change policies (Erdogan *et al*., 2020). Alternatively, the climate inaction perspective suggests that firms simply conform to regulatory and stakeholder pressures with no genuine commitment to implementing climate change policies (Haque and Ntim, 2018).

Recent empirical research has delved deeper into the determinants of a firm's commitment to climate change. For instance, using a sample of UK firms, Albitar et al. (2023) examine the impact of eco-innovation and climate governance on corporate commitment to climate change. They find that eco-innovation that captures a firm's capacity to reduce environmental costs and burdens for customers enhances corporate commitment to climate change. They also confirm that climate governance that reflects the existence of environmental committees, climate incentives and sustainability reports positively impact corporate commitment to climate change. However, how the board leadership structure especially a LIDIR representation on the board affects corporate commitment to implementing climate change policies remains largely absent in the existing literature. This is an important research question, considering that a LIDIR representation on the board assigned with specific board leadership roles can influence managerial decisions on climate change policies, leading to corporate commitment to climate change.

### *2.2 Literature review on LIDIR representation*

LIDIR is largely influential in providing a power-balancing mechanism within the board leadership structure (Krause *et al*., 2017; Rajkovic, 2020). According to the compromise board leadership structure hypothesis, a LIDIR can significantly influence managerial decisions. Existing research finds that LIDIR plays an important role in firm-level

outcomes. More specifically, a LIDIR representation on the board improves firm performance (Krause *et al*., 2017; Lamoreaux *et al*., 2019), investment efficiency (Rajkovic, 2020), decreases managerial risk-taking and cost of debt (Owusu *et al*., 2023), and reduces earnings manipulation (Hsu *et al*., 2024). However, Shi and Connelly (2018) document that the mandatory rather than organic adoption of a LIDIR is a symbolic management tactic to please regulators, making it less beneficial.

In the accounting, finance and management literature, most studies have focused on the influence of a LIDIR on firm financial outcomes including firm performance, earnings management, managerial risk-taking and cost of debt. However, research on the implications of a LIDIR, especially on non-financial outcomes such as climate change commitment that reflects the firm-stakeholder relationship, is virtually non-existent, considering their authority and remit in the board leadership structure. In addition, lead independent directors have led the charge in climate change-related issues as in the case of Dame Amanda Blanc in BP plc. Therefore, it is important and timely to investigate how a LIDIR representation on the board affects a firm's commitment to climate change. Moreover, since a LIDIR has proven to be influential and has the authority and remit to resolve conflicts between boards and managers, research on a firm's commitment to climate change can serve as a reference for addressing climate change issues through board leadership structure. As such, this study enriches the literature on the effectiveness of a LIDIR from the perspective of a firm's commitment to climate change.

### *2.3 Hypotheses development*

In order to elucidate the relationship between a LIDIR and a firm's commitment to climate change, we rely on three primary arguments. First, consistent with the compromise board leadership theory (Krause *et al*., 2017), the appointment of a LIDIR can balance the

unity of command (i.e., CEO chair) supported by stewardship theory (Fayol, 1949; Pfeffer, 1981; Dalton *et al*., 1998) and independent monitoring (i.e., role separation) propagated by the agency theory (Fama and Jensen, 1983)[5]. From the climate change commitment perspective, we argue that having a CEO chair without independent monitoring mechanism could encourage greenwashing agenda and generate a positive impression across different stakeholders with less effectual. When firms appoint a LIDIR to demonstrate power-balancing mechanism through effective leadership and strong oversight, they are likely to allow the board leadership to take decisive actions and effectively respond to climate change challenges. Despite the significance of the compromise board leadership structure theory in understanding board leadership dynamics, there is scarcity of empirical evidence supporting its validity. In our case, with lead independent directors looking to advance climate change commitment and respond to investors demand and other stakeholder pressures, they are more likely to enhance a firm's commitment to climate change. It is likely that, they will use their assigned specific board leadership roles to facilitate effective managerial decisions associated with climate change-related issues and enhance their firm's commitment to climate change.

Second, as the interest in climate change issues is growing, the demand for a firm's commitment to climate change is increasing as demonstrated in the ExxonMobil case above. Lead independent directors are particularly interested in their firm's commitment to climate change, as they are likely to receive threat for re-election if they fail to initiate/support the implementation of climate change-related proposals. Considering that climate-focused investors can threaten to vote against directors who do not support climate-related proposals, lead independent directors may have the incentives to influence managerial decisions in favour of more commitment to climate change.

[5] While the proponents of stewardship theory argue that a CEO chair allows clear lines of authority and responsibility as well as quick/effective decision making, the proponents of agency theory argue that in the absence of independent monitoring CEO chair leads to entrenchment and higher agency costs. Compromise board leadership structure theory however seeks to reconcile these two contrasting positions.

Third, prior research shows that board independence is likely to have significant influence in inducing managers to commit to climate change initiatives (Albitar *et al*., 2023). Accordingly, lead independent directors assigned with specific board leadership roles may drive managerial decisions towards the implementation of strong climate change-related policies that result in more commitment to climate change. As highlighted earlier, lead independent directors have been actively involved and committed to advancing climate change-related initiatives within their firms and beyond. Recent research has, however, paid little attention to what extent lead independent directors affect their firm's commitment to climate change.

Taken together, the preceding discussion shows that lead independent directors are likely to influence firms towards more commitment to climate change. We, thus, propose our first hypothesis as follows:

***Hypothesis 1: Lead independent director representation on the board is positively associated with a firm's commitment to climate change.***

Next, previous studies have paid little attention to improving our understanding of the differential effect of a LIDIR in firms with a CEO chair and in firms with a non-CEO chair. There may be significant differences in board and manager conflicts and the scrutiny undertaking by lead independent directors between firms with a CEO chair and firms with a non-CEO chair, which may drive the relationship between a LIDIR representation on the board and a firm's commitment to climate change. Thus, we investigate this underlying mechanism through which a LIDIR representation may increase a firm's commitment to climate change.

From the board leadership structure perspective, Owusu *et al*. (2023) focus on the differential effect of a LIDIR on managerial risk-taking in firms with an independent board chair and in firms with a non-independent board chair. They report that lead independent

directors are more effective in decreasing managerial risk-taking in firms with a non-independent board chair than in firms with an independent board chair. To the extent that lead independent directors are more effective in firms with a non-independent board chair than in firms with an independent board chair, we argue that their effect on a firm's commitment to climate change may differ in firms with CEO chair compared with non-CEO chair firms due to the level of board and manager conflicts and the associated scrutiny visible in the two contrasting board leadership structures.

Drawing from the preceding discussion and to the extent that the two board leadership structures (CEO chair and non-CEO chair) may show different board and manager conflicts and the level of scrutiny, we expect a significant difference in the impact of lead independent directors on their firm's commitment to climate change. Thus, our second hypothesis is stated as follows:

***Hypothesis 2: The positive relationship between a lead independent director representation on the board and a firm's commitment to climate change is stronger in firms with CEO chair compared with the non-CEO chair firms.***

Lastly, we investigate the previously unaddressed question of how a firm's commitment to climate change affects its ESG performance in the presence of a LIDIR. Extant research (e.g., Cucari *et al*., 2018; Husted and de Sousa-Filho, 2019; Arayssi *et al*., 2020; Menicucci and Paolucci, 2022) has distinctively focused on the relationship between board independence and ESG performance, and evidence that board independence positively impacts ESG performance. We explore to what extent a firm's commitment to climate change can be influenced by a LIDIR representation on the board to increase ESG performance. Improving our understanding of how a LIDIR representation on the board drives a firm's commitment to climate change to increase ESG performance is important because poor ESG practices is likely to result in a negative media coverage, which can lead to a negative stock

market reaction (Xu *et al*., 2016). Considering that investors react negatively to poor ESG performance, lead independent directors are likely to influence managerial decisions towards more commitment to the implementation of climate change policies to improve ESG performance. As predicted earlier, if a LIDIR representation on the board increases a firm's commitment to implementing climate change policies, we would expect ESG performance to improve in the presence of a LIDIR. Thus, ESG performance is more likely to improve when a firm commit to the implementation of climate change policies in the presence of a LIDIR.

Based on the preceding discussion, if a LIDIR representation on the board result in an improvement in a firm's commitment to climate change, then we expect a firm's commitment to climate change in the presence of a LIDIR to increase ESG performance. Therefore, our third hypothesis is stated as follows:

***Hypothesis 3: ESG performance increases when firms commit to climate change in the presence of a LIDIR on the board.***

## 3. Research design

### *3.1 Data and sample selection*

We develop our sample from three main sources. First, we retrieved the LIDIR data from the BoardEx North America Employment file, which has different titles for board roles. In common with the existing literature (Lamoreaux *et al*., 2019; Rajkovic, 2020), we classified any board roles with the titles lead independent trustee, lead independent director, facilitating director, lead outside director, lead director, presiding director, lead trustee, and presiding trustee as a LIDIR. As in Lamoreaux *et al*. (2019) and Rajkovic (2020), we exclude non-executive board chair from this group of titles. In addition to the LIDIR data, we obtained other board-level characteristics data from the BoardEx database. Second, the data to construct the commitment to climate change composite score and ESG score is obtained

from the Refinitiv ESG database. Third, we collect the firm-level financial data from the Thomson Reuters Worldscope database.

Regarding the sample selection procedure, we first merge the data from the three databases and delete observations without sufficient data to calculate the commitment to climate change composite score. Next, we delete observations that operate in the financial services industry (i.e., SIC code 6000-6999). We also exclude observations with insufficient data to calculate the control variables. The final sample we use to undertake our analysis consist of 12,236 US listed firm-year observations between 2002 and 2019.[6]

*3.2 Empirical model*

To test hypotheses 1 and 2, we estimate the ordinary least squares (OLS) regression in equation (1) below:

$$FCCC_{i,t} = \alpha + \beta_1.D\_Lead_{i,t} + \beta_2.Controls_{i,t} + \beta_3.Year\_FE_t + \beta_4.Industry\_FE_i + \epsilon_{i,t} \quad (1)$$

where *D_Lead* is a dummy variable coded as 1 for each firm-year observation, with the board role capturing any of the LIDIR titles in subsection 3.1, and 0 otherwise. In our robustness analysis, we employ two alternative measurements – LIDIR as a fraction of the number of board members (*P_Lead1*) and LIDIR as a fraction of the number of independent directors (*P_Lead2*). Following Albitar et al. (2023), we construct the variable measuring a firm's commitment to climate change (*FCCC*) by utilising four distinctive climate change policies that have been confirmed to lead to corporate commitment to climate change. More specifically, and consistent with Albitar *et al*. (2023), we use a dummy variable - (i) coded as 1 if a firm has a policy that supports SDG 13 on climate action, and 0 otherwise, (ii) coded as

[6] We limit our sample to 2019 to avoid the impact of the coronavirus (COVID-19) pandemic, which intensified in 2020 and thereafter, allowing us to focus on financial year ends unaffected by the disruptions of the global pandemic.

1 if a firm has a policy that recognises the commercial risks and opportunities from climate change, and 0 otherwise, (iii) coded as 1 if a firm discloses Scope 3 $CO_2$ emissions, and 0 otherwise, and (iv) coded as 1 if a firm sets emissions reduction target, and 0 otherwise. To capture the aggregate *FCCC*, we add the scores of all four components for each firm-year observation, resulting in a maximum of 4 if a firm has implemented the policies and reports on all of them or a minimum of 0 if a firm has not committed to any of the four policies and reported on them. Therefore, a firm with a higher value of *FCCC* is more committed to climate change and vice versa.

Following prior research (e.g., Albitar *et al*., 2023; Orazalin *et al*., 2023), we control for board-level and firm-level variables in our primary regression. For the board-level variables, we include board size (*BoDsize*), percentage of independent directors on the board (*P_IndDir*), percentage of independent women directors on the board (*P_IndWDir*), CEO gender (*FCEO*), CEO chair (*CEOChair*), number of board meetings (*BoDmeet*), and the presence of environmental committee (*ENVcomtte*). Regarding the firm-level variables, we control for capital intensity (*CAPINT*), firm size (*SIZE*), return on assets (*ROA*), market-to-book value (*MTBV*), free cash flow *(CASH*), intangible assets intensity (*INTANG*), liquidity (*LIQ*), and firm age (*FIRMAGE*). Appendix 1 contains the detailed variable definitions. We also control for year and industry fixed effects, and standard errors are clustered at firm and year level (i.e., dual cluster). In addition, we winsorise all continuous variables at the 1st and 99th percentile to eliminate the potential bias of outliers.

To test hypothesis 3, we estimate the interaction between *FCCC* and *D_Lead* on ESG performance utilising the OLS regression in equation (2) below:

$$ESGscore_{i,t} = \alpha + \beta_1.FCCC_{i,t} + \beta_2.D\_Lead_{i,t} + \beta_3.FCCC \times D\_Lead_{i,t} + \beta_4.Controls_{i,t} + \beta_5.Year\_FE_t + \beta_6.Industry\_FE_i + \epsilon_{i,t} \quad (2)$$

where all variables in equation (2) are defined under equation (1) except *ESGscore*, which is measured as the aggregate score of environmental (*ENVscore*), social (*SOCscore*), and corporate governance (*GOVscore*) pillars to proxy ESG performance. Our main variable of interest in equation (2) is the interaction between a firm's commitment to climate change and a LIDIR representation on the board (*FCCC* × *D_Lead*). As a robustness test, we repeat equation (2) and utilise each of the three pillars (i.e., *ENVscore*, *SOCscore*, and *GOVscore*) as a dependent variable in place of *ESGscore*.

## 4. Results and Analysis

### *4.1 Descriptive statistics*

Table 1 presents the descriptive statistics for all the main variables. The mean value of a firm's commitment to climate change (FCCC) is around 0.44, with a minimum value of 0 and a maximum value of 4. The 0.44 is significantly lower than the 1.27 Albitar *et al*. (2023) reported across UK listed firms between 2014 and 2020. This evidence suggests that UK listed firms are more committed to climate change than US listed firms. Our sample firms show a fraction of 38% with a LIDIR representation on the board. Regarding the board-level control variables, the mean value of independent directors is 72%. On average, the board size is about 11, and around 13% of the board members are women. In addition, the mean value of female CEOs of our sample firms is 4%. 65% of our sample firms have the combined CEO and board chair positions. On average, the board meets around 8 times over our sample period, and the mean value of the environmental committee is about 32%. For the firm-level control variables, the mean value of capital intensity is around 0.68, and firm size is 15.10, measured as the natural logarithm of total assets. On average, the return on assets of our sample firms is about 9%, and the market-to-book value is around 2.37. The mean value of free cash flow of our sample firms is 3.11, intangible assets intensity is 0.13, liquidity is 2.41,

and firm age is about 2.82, measured as the natural logarithm of the number of years since its incorporation. In general, the descriptive statistics show the expected variation in each variable.

Table 2 contains the correlation between the main variables. Prior research (e.g., Kennedy, 2008; Sharma *et al*., 2017; Owusu *et al*., 2022; Ullah *et al*., 2024) evidence that a correlation coefficient greater than 0.80 and the variance inflation factor (VIF) larger than 10 may indicate multicollinearity concern. In Table 2, the highest correlation coefficient of 0.55 between firm size and board size is lower than the threshold of 0.80. The highest VIF from the primary regression is 4.80 (not tabulated) concerning firm size, which is lower than the threshold of 10. Overall, the smaller correlation coefficients and VIF values show that our analysis from the main variables is not biased by multicollinearity.

**[Insert Table 1 here]**
**[Insert Table 2 here]**

*4.2 Regression results*

Table 3 presents the results of our regression tests. In Column 1, we regress a firm's commitment to climate change (*FCCC*) on our primary variable of interest, *D_Lead*, without control variables other than the year and industry fixed effects. In Column 2, we include board-level and firm-level control variables as well as the year and industry fixed effects. The coefficient on *D_Lead* from both specifications is significant at the 5% level or better, indicating that a LIDIR representation on the board positively impacts a firm's commitment to climate change. This finding is largely consistent with prior research which shows that board independence increases a firm's commitment to climate change (Albitar *et al*., 2023). Moreover, firms with a LIDIR are likely to take climate action, commit to the implementation of climate change policies and reduce their footprint in response to investors and other stakeholders' demand (Borghesi *et al*., 2015; Haque *et al*., 2016; Hollindale *et al*., 2019; Afrifa *et al*., 2020; Erdogan *et al*., 2020; Karim *et al*., 2021; Krieger and Zipperer, 2022). Our

results are also economically significant, where economic significance is calculated in line with Rajkovic (2020). For instance, utilising the cross-sectional mean of a firm's commitment to climate change (*FCCC*) in Table 1, a LIDIR representation on the board is associated with an increase in a firm's commitment to climate change from 6.3% (Column 2 = 0.028/0.443) to 25.1% (Column 1 = 0.111/0.443). Thus, our hypothesis 1 is supported.

In addition, the signs of the coefficients and the significant levels of the control variables are largely in common with those reported in the Albitar *et al*. (2023) study. For the board-level variables, *BoDsize*, *P_IndDir*, *P_IndWDir*, *BoDmeet* and *ENVcomtte* positively impact *FCCC*, suggesting that firms with larger board size, independent directors, independent women directors, a greater number of board meetings and the existence of environmental committees are committed to climate change. Concerning the firm-level variables, firm size, market-to-book ratio, intangible assets intensity and firm age positively impact a firm's commitment to climate change. These results suggest that larger and older firms with higher valuation and intangible resources are more committed to climate change.

However, a LIDIR authority and remit may be influenced by the number of board members and independent directors when making climate change decisions. Therefore, our main test variable, *D_Lead*, may not capture the real influence of a LIDIR. To address the possible problem, we utilise alternative measures of LIDIR to capture the proportional influence of a LIDIR. More specifically, we employ a LIDIR as a fraction of the number of board members (*P_Lead1*) and a LIDIR as a fraction of the number of independent directors (*P_Lead2*) as alternative measures. In Columns 3 and 4 of Table 3, *P_Lead1* and *P_Lead2* are utilised as alternative test variables. Even though the magnitude of the coefficients on *P_Lead1* and *P_Lead2* are far greater than those in Columns 1 and 2, the results remain significantly positive and support our main conclusion.

**[Insert Table 3 here]**

In Table 4, we mitigate the potential missing variables, as there may be other factors not considered in our main regressions that can influence a firm's commitment to climate change. For instance, the Albitar *et al*. (2023) study shows that eco-innovation score (*EcoInn_score*), environmental training (*ENV_train*), and climate governance (*Climate_gov*) influence a firm's commitment to climate change. Consequently, *EcoInn_score* is controlled in Column 1 of Table 4, *ENV_train* is controlled in Column 2, *Climate_gov* is controlled in Column 3, and all three variables are controlled in Column 4. In common with Albitar *et al*. (2023), these additional control variables are defined as follows. (1) *EcoInn_score* is downloaded directly from the Refinitiv ESG database, which ranges from 0 to 100, and captures a firm's ability to reduce environmental costs to benefit consumers using new technologies to create new market opportunities. (2) *ENV_train* is a dummy variable coded as 1 if a firm has an environmental training programme, and 0 otherwise. (3) *Climate_gov* is calculated as a composite score of the presence of three climate governance elements of which each is coded as 1 if a firm - has a board-level environmental committee, provides climate incentives for individual management, publishes sustainability reports, and 0 otherwise for each element. The results from re-estimating equation (1) show that the coefficient on our main test variable (*D_Lead*) remains significantly positive, further validating our main conclusion.

To the extent that the SDGs were born at the United Nations (UN) Conference on Sustainable Development in Rio de Janeiro 2012, and the subsequent establishment of SDG 13 at the UN Assembly in 2015, a firm's commitment to climate change (FCCC) may be impacted by these climate change reforms. In addition, the disclosure of scope 3 emissions started shortly after 2011. Even though the sustainability goals were first discussed in the 1990s, these climate change reforms may have influenced firms to become more committed to climate change than the pre-climate change reform period. As Appendix 2 shows, more

firms acknowledged the importance of climate change-related issues following the establishment of SDG 13 at the UN Assembly in 2015. In a supplementary test in Table 5, we re-estimate equation (1) by splitting our sample into pre-SDGs (2002-2014) and SDGs (2015-2019) periods to check the sensitivity of our main results. The results in Columns 1 and 2 show that the coefficients on *D_Lead* from both specifications are significantly positive and support our main conclusion[7]. However, the result is more pronounced in firms during the SDGs period (Column 2) than in pre-SDGs period. These results suggest that international climate change reforms are important in educating lead independent directors on the negative impact and the threat of not addressing climate change-related concerns, thereby enhancing their firm's commitment to climate change.

Overall, our regression results of a significant and positive association between a LIDIR representation on the board and a firm's commitment to climate change supports the compromise board leadership structure theory (Krause *et al*., 2017; Rajkovic, 2020), in that a LIDIR has the authority and remit to influence managerial decisions to implement climate change policies that address climate change issues, which then increases a firm's commitment to climate change. These results imply that a LIDIR is aware of the expectations of different stakeholders on climate change and, therefore, makes every effort to influence the implementation of climate change policies to meet their demands. We conclude that a LIDIR influences a firm's commitment to climate change, especially during the SDGs period.

**[Insert Table 4 here]**
**[Insert Table 5 here]**

*4.3 Endogeneity test*

By matching a LIDIR with each firm, the independent variable, *D_Lead*, is a variable at the firm level. Since increased commitment to climate change only becomes observable

[7] As an additional test, we split our sample into pre-SDGs (2002-2012) and SDGs (2013-2019) and re-estimate equation (1) but the results (untabulated) are qualitatively similar to those reported in Table 5.

when a firm has a LIDIR representation on the board, the commitment to climate change of firms without a LIDIR becomes unobservable. Hence, there is a possibility that our main results may be subject to some endogenous problems caused by dissimilarities between firms with and those without a LIDIR representation on the board. Additionally, firms with poor commitment to climate change may appoint a LIDIR as a power-balancing mechanism to influence climate change-related decisions. Alternatively, firms may appoint a LIDIR as a symbolic management tactic to satisfy regulators with less effectual (Shi and Connelly, 2018) or to prevent the separation of CEO and board chair positions (Dalton and Dalton, 2005; Krause *et al*., 2017) even if they are committed to climate change. Therefore, our main results may be spurious due to self-selection bias, omitted variable bias and reverse causality. To further check the robustness of our results, we utilised various techniques such as propensity score matching, Heckman two-step and instrumental variable approach to confirm our main results.

In common with prior research (e.g., Ullah *et al*., 2022; Albitar *et al*., 2023; Owusu et al., 2024), we mitigate endogeneity concerns by utilising the propensity score matching (PSM) technique on the matched sample. In the first stage, we estimate probit regression to determine the probability of a firm appointing a LIDIR utilising *D_Lead* as the dependent variable, the board-level and firm-level variables, and the year and industry fixed effects as the explanatory variables. In Panel A of Table 6 (Column 1), the results show that a number of the explanatory variables are statistically significant with the pseudo $R^2$ of 0.237. In the second stage, we utilise the nearest neighbour matching technique with 1% maximum PSM difference to guarantee that the matched sample is satisfactorily identical. In addition, we utilise two diagnostic tests to confirm that our matching process is successful. In Column 2 of Panel A, the first test results after re-estimating the probit regression show that the coefficients on the explanatory variables have become smaller and insignificant in addition to

a noticeably decreased pseudo $R^2$ from 0.237 in Column 1 to 0.002 in Column 2. These test results show that our matching process successfully removes the observable differences across our sample firms. We also utilise the test for differences in mean for the pre-match and the post-matched sample as a second diagnostic test, and the results are reported in Panel B of Table 6. As the test results show, the significant differences between the pre-match variables disappear in the post-matched variables, confirming the removal of the observable differences in the matched sample. In Panel A (Column 3) of Table 6, we report the OLS regression results from re-estimating equation (1) for the matched sample, which show that the coefficient on *D_Lead* is significantly positive, indicating that our main results are unchanged.

**[Insert Table 6 here]**

As in Albitar *et al*. (2023), we utilise the Heckman two-step approach to mitigate self-selection bias. In the first step, we estimate the probit regression to determine the likelihood of appointing a LIDIR utilising *D_Lead* as the dependent variable and board-level and firm-level variables as the explanatory variables. The results are reported in Column 1 of Table 7. In the second step, we utilise the predicted parameters from Column 1 to calculate the inverse mills ratio (Mills), which is controlled in Column 2. The OLS regression results from re-estimating equation (1) show that the coefficient on *D_Lead* in Column 2 is significantly positive, further confirming the robustness of our results.

**[Insert Table 7 here]**

To further mitigate endogeneity concerns, we follow prior research on LIDIR (Lamoreaux *et al*., 2019; Rajkovic, 2020; Owusu *et al*., 2023) and utilise the instrumental variable (IV) approach to mitigate omitted variable bias and reverse causality. According to Caramanis and Lennox (2008), 1-year lagged board-level variables are powerful instruments

to predict the current year's board-level variables. As in Owusu *et al*. (2023), we utilise a 1-year lagged LIDIR ($D\_Lead_{t-1}$) and the control variables in equation (1) to instrument our main test variable, *D_Lead*, and the results from the first stage in Columns 1, 3 and 5 of Table 8 are significantly positive. Utilizing three different IV estimation methods, including two-stage least squares (2SLS) and limited information maximum likelihood (LIML) in the second stage as well as the system generalised method of moments (GMM), the coefficients on *D_Lead* in Columns 2, 4 and 6 of Table 8 are significantly positive, which confirms our main conclusion.

**[Insert Table 8 here]**

*4.4 Firms with a CEO chair versus firms with a non-CEO chair*

Turning to our second hypothesis, we have argued that firms with the combined CEO and board chair positions may be more scrutinised by a LIDIR than other firms with separate positions, as board and manager conflicts may be highly visible in the former board leadership structure. To the extent that a LIDIR was introduced in the early 2000s to prevent the separation of CEO and board chair positions (Dalton and Dalton, 2005; Krause *et al*., 2017), we investigate whether lead independent directors might behave differently towards a firm's commitment to climate change in the two groups of firms. Therefore, unlike prior LIDIR research (i.e., Krause *et al*., 2017; Shi and Connelly, 2018; Lamoreaux *et al*., 2019; Rajkovic, 2020; Owusu *et al*., 2023; Hsu *et al*., 2024) that has not analysed the effectiveness of a LIDIR in two distinctive board leadership structures (i.e., CEO chair versus non-CEO chair), we predict that the positive relationship between a LIDIR representation on the board and a firm's commitment to climate change will be stronger in firms with a CEO chair than in non-CEO chair firms.

To empirically test our prediction, we re-estimate equation (1) by splitting our sample into firms with the combined CEO and board chair positions and firms with both positions

separated and the results are reported in Table 9. As Columns 1 and 2 of Table 9 show, the coefficients on *D_Lead* from both specifications are significantly positive. As expected, the result is more pronounced in firms with the combined CEO and board chair positions (Column 1) than in other firms (Column 2), implying that our hypothesis 2 is supported. Our results are also generally consistent with Owusu *et al*.'s (2023) findings that lead independent directors are more effective in firms with non-independent board chair than firms with independent board chair. This strong new evidence suggests that a LIDIR is more influential in firms with the combined CEO and board chair positions than if both positions are separated, further confirming the motivation of US regulators.

**[Insert Table 10 here]**

*4.5 LIDIR, Climate change commitment and ESG performance*

In this section, we explore the implications of increased commitment to climate change in the presence of a LIDIR for ESG performance. To the extent that a LIDIR representation on the board increases a firm's commitment to climate change as reported in subsection 4.2, we empirically test our third hypothesis. We have argued that due to investors negative reaction to poor ESG performance and especially the threat to directors' re-election, lead independent directors are likely to have the incentives to drive managerial decisions towards more commitment to climate change and thereby improve ESG performance. If the reported increase in a firm's commitment to climate change is due to the presence of a LIDIR representation on the board, then we would expect ESG performance to improve as climate change concerns will be addressed by the presence of a LIDIR.

In Table 10, we estimate equation (2), and the main results are reported in Column 1, which show that the coefficient on the interaction term, *FCCC* × *D_Lead*, is significant and positively associated with *ESGscore*. Among the board-level control variables, *BoDsize*, *P_IndDir*, *P_IndWDir*, *FCEO*, *BoDmeet* and *ENVcomtte* positively impact *ESGscore*,

indicating that firms with larger board size, independent directors, women directors, female CEO, higher number of board meetings and the existence of environmental committee have better ESG performance. In respect of the firm-level control variables, firm size, return on assets, market-to-book value, free cash flow, intangible resources, and firm age positively impact ESG performance. In addition, we decompose *ESGscore* into *ENVscore*, *SOCscore* and *GOVscore* and re-estimate equation (2) using each of the three components as dependent variable in Columns 2, 3 and 4 of Table 10, respectively. The results show that the coefficient on the interaction term, *FCCC* × *D_Lead*, consistently positively and significantly impacts on ESG performance across all the three specifications.

Our results suggest that increased commitment to climate change leads to improved ESG performance in the presence of a LIDIR on the board, which supports our hypothesis 3. These results show that ESG rating agencies appreciate the positive association between a LIDIR representation on the board and a firm's commitment to climate change, reflecting in ESG performance. The results are also in common with the interpretation that a LIDIR as a power-balancing mechanism has the potential to align climate change policies to meet the expectations of the wider stakeholders, which will then mitigate the risks associated with regulatory changes/compliance, environmental impacts, and meeting investors demand, thereby improving ESG performance. Our results provide new insights and enhance our understanding of ESG performance effect of a firm's commitment to the implementation of climate change policies in the presence of a LIDIR.

**[Insert Table 10 here]**

## 5. Conclusions

This paper documents new evidence on the leadership role of a LIDIR in climate change and ESG outcomes. Using a large sample of US listed firms over the period of 2002 to 2019, we investigate how a LIDIR representation on the board affects a firm's

commitment to climate change and whether this effect leads to ESG performance. This important board leadership role has proven influential in resolving conflicts between boards and managers. We find that a LIDIR representation on the board positively impacts a firm's commitment to climate change. This result still holds after utilising other measures of a LIDIR and controlling for various potential missing variables. The positive association between a LIDIR representation on the board and a firm's commitment to climate change remains robust after implementing PSM, Heckman two-step and instrumental variable techniques. In addition, when we compare the effectiveness of lead independent directors in firms with a CEO chair and non-CEO chair firms, our evidence suggests significant difference between the two board leadership structures. We also find strong new evidence that increased commitment to climate change leads to better ESG performance in the presence of a LIDIR. These results show that a LIDIR representation on the board is a power-balancing mechanism, especially when the CEO and board chair positions are combined, which influences the implementation of climate change policies to meet the expectations of different stakeholders and increases ESG performance.

Overall, our paper makes new and important contributions to the existing literature on a LIDIR role in the board leadership structure as it advances new knowledge and improves our understanding of how corporate commitment to climate change is affected by a LIDIR representation on the board. More precisely, our paper extends prior research on a LIDIR role in firm-level outcomes by investigating the association between a LIDIR and a firm's commitment to climate change. Our results are in common with the growing literature showing that a LIDIR is influential on firm-level outcomes (Krause *et al*., 2017; Shi and Connelly, 2018; Lamoreaux *et al*., 2019; Rajkovic, 2020; Owusu *et al*., 2023; Hsu *et al*., 2024). It also adds to a stream of literature explaining corporate commitment to climate change (e.g., Albitar *et al*., 2023) by providing the first evidence to show that a LIDIR

representation on the board is a new determinant of corporate commitment to climate change, as they have the potential to mitigate risks associated with regulatory changes/compliance, environmental impacts, meeting investors demand, and thus improve ESG performance. Our evidence shows that a LIDIR representation on the board can significantly and positively impact climate change and ESG outcomes, which provides important implications for policymakers outside the US jurisdiction seeking to address climate change issues and ESG performance.

Like any other studies in this area, our study is not without some limitations. First, as we focus on US listed firms over the period 2002-2019, the generalisation of our results to other listed firms beyond the US setting is limited. With the recent adoption of a LIDIR policy across European countries, future research could explore whether the findings apply to listed firms in these countries where corporate governance environments are substantially different. Second, our study is limited to a firm's commitment to climate change, a measure that is somewhat subjective. Future research could consider objective measures such as greenhouse gas emitted by firms or renewable energy consumption to proxy non-financial outcomes. Finally, and as in previous LIDIR studies, our study focuses on the mere representation of a LIDIR on the board without considering their two main board roles (i.e., monitoring and advisory). Future studies may consider investigating how monitoring versus advisory roles of a LIDIR affect firm-level outcomes.

**References:**


Afrifa, G. A., Tingbani, I., Yamoah, F. and Appiah, G. (2020). "Innovation input, governance and climate change: Evidence from emerging countries", *Technological Forecasting and Social Change*, Vol. 161 No. 1, 120256.

Albitar, K., Al-Shaer, H. and Liu, Y. S. (2023). "Corporate commitment to climate change: the effect of eco-innovation and climate governance" *Research Policy*, Vol. 52 No. 2, Article 104697.

Alianz Global Investors (2022). "Why German companies should embrace the role of lead independent director", retrieved from https://www.allianzgi.com/en/insights/outlook-and-commentary/german-lead-independent-directors.

Arayssi, M., Jizi, M. and Tabaja, H. H. (2020). "The impact of board composition on the level of ESG disclosures in GCC countries", *Sustainability Accounting, Management and Policy Journal*, Vol. 11 No. 1, pp.137-161.

Benlemlih, M., Arif, M. and Nadeem, M. (2023). "Institutional ownership and greenhouse gas emissions: a comparative study of the UK and the USA", *British Journal of Management*, Vol. 34 No. 2, pp. 623-647.

Borghesi, S., Cainelli, G. and Mazzanti, M. (2015). "Linking emission trading to environmental innovation: Evidence from the Italian manufacturing industry", *Research Policy*, Vol. 44 No. 3, pp. 669-683.

Cucari, N., Esposito De Falco, S. and Orlando, B. (2018). "Diversity of board of directors and environmental social governance: Evidence from Italian listed companies", *Corporate Social Responsibility and Environmental Management*, Vol. 25 No. 3, pp. 250-266.

Dalton, C. M. and Dalton, D. R. (2005). "Boards of directors: Utilizing empirical evidence in developing practical prescriptions", *British Journal of Management*, Vol. 16 No. 1, pp. S91-S97.

Davies, P. L. and Hopt, K. J. (2013). "Corporate boards in Europe—accountability and convergence", *The American Journal of Comparative Law*, Vol. 61 No. 2, pp. 301-376.

Erdoğan, S., Yıldırım, S., Yıldırım, D. Ç. and Gedikli, A. (2020). "The effects of innovation on sectoral carbon emissions: Evidence from G20 countries" *Journal of Environmental Management*, Vol. 267 No. 1, 110637.

Gregory, H. J. and Austin, S. (2019). *Looking ahead: key trends in corporate governance. Harvard Law School Forum on Corporate Governance*, retrieved from https://corpgov.law.harvard.edu/2019/01/10/looking-ahead-key-trends-in-corporate governance/.

Haque, F. and Ntim, C. G. (2018). "Environmental policy, sustainable development, governance mechanisms and environmental performance", *Business Strategy and the Environment*, Vol. 27 No. 3, pp. 415-435.

Haque, S., Deegan, C. and Inglis, R. (2016). "Demand for, and impediments to, the disclosure of information about climate change-related corporate governance practices", *Accounting and Business Research*, Vol. 46 No. 6, pp. 620-664.

Hollindale, J., Kent, P., Routledge, J. and Chapple, L. (2019). "Women on boards and greenhouse gas emission disclosures", *Accounting and Finance*, Vol. 59 No. 1, pp. 277-308.

Hsu, Y. T., Lee, C. F., Lin, C. Y. and Tang, N. (2024). "Lead independent director and earnings management. *European Financial Management*, Vol. 30 No. 1, pp. 3-54.

Husted, B. W. and de Sousa-Filho, J. M. (2019). "Board structure and environmental, social, and governance disclosure in Latin America" *Journal of Business Research*, Vol. 102, pp. 220-227.

Karim, A. E., Albitar, K. and Elmarzouky, M. (2021). "A novel measure of corporate carbon emission disclosure, the effect of capital expenditures and corporate governance. *Journal of Environmental Management*, Vol. 290, 112581.

Kennedy, P. (2008). *A guide to econometrics , John Wiley and Sons.*

Kesidou, E. and Demirel, P. (2012). "On the drivers of eco-innovations: Empirical evidence from the UK", *Research policy*, Vol. 41 No. 5, pp. 862-870.

Krause, R., Withers, M. C. and Semadeni, M. (2017). "Compromise on the board: Investigating the antecedents and consequences of lead independent director appointment", *Academy of Management Journal*, Vol. 60 No. 6, pp. 2239-2265.

Krieger, B. and Zipperer, V. (2022). "Does green public procurement trigger environmental innovations?", *Research Policy*, Vol. 51 No. 6, 104516.

Lamoreaux, P. T., Litov, L. P. and Mauler, L. M. (2019). "Lead Independent Directors: Good governance or window dressing?", *Journal of Accounting Literature*, Vol. 43 No. 1, pp. 47-69.

Lin, B. and Zhu, J. (2019). "The role of renewable energy technological innovation on climate change: Empirical evidence from China", *Science of the Total Environment*, Vol. 659, pp. 1505-1512.

Matsumura, E. M., Prakash, R. and Vera-Munoz, S. C. (2014). "Firm-value effects of carbon emissions and carbon disclosures", *The Accounting Review*, Vol. 89 No. 2, pp. 695-724.

Menicucci, E. and Paolucci, G. (2022). "Board Diversity and ESG Performance: Evidence from the Italian Banking Sector", *Sustainability*, Vol. 14 No. 20, 13447.

National Association of Corporate Directors (NACD). (2004). *Report of the NACD Blue Ribbon Commission on board leadership*. National Association of Corporate Directors.

Orazalin, N. S., Ntim, C. G., & Malagila, J. K. (2023). Board sustainability committees, climate change initiatives, carbon performance, and market value. *British Journal of Management*, Vol. 35 No. 1, pp. 295-320.

Owusu, A., O'Sullivan, N., Kwabi, F. and Holmes, M. D. (2024). "Why do female lead auditors charge a fee premium? evidence from the UK audit market", *Journal of International Accounting, Auditing and Taxation*, Val. 57, 100650.

Owusu, A., Kwabi, F., Owusu-Mensah, R. and Elamer, A. A. (2023). "Lead independent director, managerial risk-taking and cost of debt: Evidence from UK", *Journal of International Accounting, Auditing and Taxation*, Vol. 53, 100576.

Owusu, A., Kwabi, F., Ezeani, E. and Owusu-Mensah, R. (2022). "CEO tenure and cost of debt", *Review of Quantitative Finance and Accounting*, 59(2), 507-544.

Rajkovic, T. (2020). "Lead independent directors and investment efficiency", *Journal of Corporate Finance*, Vol. 64, 101690.

Sharma, D. S., Tanyi, P. N. and Litt, B. A. (2017). "Costs of mandatory periodic audit partner rotation: Evidence from audit fees and audit timeliness" *Auditing: A Journal of Practice and Theory*, Vol. 36 No. 1, pp. 129-149.

Shi, G., Sun, J. and Zhang, L. (2018). "Product market competition and earnings management: A firm-level analysis". *Journal of Business Finance and Accounting*, Vol. 45 Nos. 5-6, pp. 604-624.

The Institute of Directors. (2018). *What is the role of the Senior Independent Director?*, retrieved from https://www.iod.com/news/news/articles/What-is-the-role-of-thesenior-independent-director.

Ullah, F., Owusu, A. and Elamer, A. A. (2024). “New Blood Brings Change: Exploring the Link between Rookie Independent Directors and Corporate Cash Holdings”, *Long Range Planning*, Vol. 57 No. 4, 102451.

Ullah, F., Jiang, P., Elamer, A. A. and Owusu, A. (2022). “Environmental performance and corporate innovation in China: The moderating impact of firm ownership”, *Technological Forecasting and Social Change*, Vol. 184, 121990.

Walls, J. L., Berrone, P. and Phan, P. H. (2012). “Corporate governance and environmental performance: Is there really a link?”, *Strategic Management Journal*, Vol. 33 No. 8, pp. 885-913.

Xu, X. D., Zeng, S. X., Zou, H. L. and Shi, J. J. (2016). “The impact of corporate environmental violation on shareholders' wealth: A perspective taken from media coverage”, *Business Strategy and the Environment*, Vol. 25 No. 2, pp. 73-91.

Table 1: Descriptive Statistics

| | *N* | Mean | SD | Min | Q1 | Median | Q3 | Max |
|---|---|---|---|---|---|---|---|---|
| FCCC | 12236 | 0.443 | 0.758 | 0.000 | 0.000 | 0.000 | 1.000 | 4.000 |
| D_Lead | 12236 | 0.380 | 0.485 | 0.000 | 0.000 | 0.000 | 1.000 | 1.000 |
| BoDsize | 12236 | 11.057 | 3.753 | 1.000 | 8.000 | 11.000 | 14.000 | 36.000 |
| P_IndDir | 12236 | 0.724 | 0.090 | 0.000 | 0.778 | 0.846 | 0.900 | 1.000 |
| P_IndWDir | 12236 | 0.128 | 0.095 | 0.000 | 0.071 | 0.125 | 0.188 | 0.556 |
| FCEO | 12236 | 0.041 | 0.199 | 0.000 | 0.000 | 0.000 | 0.000 | 1.000 |
| CEOChair | 12236 | 0.653 | 0.476 | 0.000 | 0.000 | 1.000 | 1.000 | 1.000 |
| BoDmeet | 12236 | 7.780 | 3.523 | 1.000 | 5.000 | 7.000 | 9.000 | 49.000 |
| ENVcomtte | 12236 | 0.312 | 0.463 | 0.000 | 0.000 | 0.000 | 1.000 | 1.000 |
| CAPINT | 12236 | 0.680 | 0.163 | 0.413 | 0.595 | 0.705 | 0.791 | 1.606 |
| SIZE | 12236 | 15.076 | 1.513 | 9.329 | 14.148 | 15.029 | 16.007 | 20.497 |
| ROA | 12236 | 0.085 | 0.124 | -0.971 | 0.048 | 0.091 | 0.141 | 0.500 |
| MTBV | 12236 | 2.366 | 1.713 | 0.287 | 1.339 | 1.833 | 2.775 | 23.158 |
| CASH | 12236 | 3.109 | 3.380 | 0.000 | 0.048 | 0.122 | 0.317 | 3.276 |
| INTANG | 12236 | 0.313 | 0.218 | 0.000 | 0.126 | 0.284 | 0.470 | 0.963 |
| LIQUIDITY | 12236 | 2.410 | 2.346 | 0.079 | 1.272 | 1.822 | 2.735 | 16.843 |
| FIRMAGE | 12236 | 2.811 | 0.897 | 0.000 | 2.398 | 3.045 | 3.526 | 3.850 |

Continuous variables are winzorised to adjust for outliers. Variable definitions are detailed in Appendix 1.

Table 2: Correlation matrix

| | (1) | (2) | (3) | (4) | (5) | (6) | (7) | (8) | (9) | (10) | (11) | (12) | (13) | (14) | (15) | (16) | (17) |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| (1) FCCC | 1.00 | | | | | | | | | | | | | | | | |
| (2) D_Lead | 0.10*** | 1.00 | | | | | | | | | | | | | | | |
| (3) P_IndDir | 0.26*** | 0.12*** | 1.00 | | | | | | | | | | | | | | |
| (4) BoDsize | 0.20*** | 0.19*** | 0.35*** | 1.00 | | | | | | | | | | | | | |
| (5) P_IndWDir | 0.15*** | 0.10*** | 0.08*** | 0.12*** | 1.00 | | | | | | | | | | | | |
| (6) FCEO | 0.02** | -0.01 | -0.01 | -0.01 | 0.08*** | 1.00 | | | | | | | | | | | |
| (7) CEOChair | -0.04*** | 0.42*** | 0.14*** | 0.18*** | -0.02** | -0.07*** | 1.00 | | | | | | | | | | |
| (8) BoDmeet | 0.02*** | -0.03*** | 0.01 | -0.01 | 0.01 | 0.01 | -0.08*** | 1.00 | | | | | | | | | |
| (9) ENVcomtte | 0.48*** | 0.07*** | 0.26*** | 0.24*** | 0.11*** | 0.02** | 0.04*** | 0.01 | 1.00 | | | | | | | | |
| (10) CAPINT | -0.10*** | -0.03*** | -0.16*** | -0.17*** | -0.09*** | -0.03*** | -0.10*** | -0.04*** | -0.09*** | 1.00 | | | | | | | |
| (11) SIZE | 0.44*** | 0.09*** | 0.55*** | 0.35*** | 0.03*** | -0.03*** | 0.18*** | 0.07*** | 0.40*** | -0.16*** | 1.00 | | | | | | |
| (12) ROA | 0.11*** | 0.04*** | 0.22*** | 0.14*** | -0.01 | -0.02** | 0.15*** | -0.09*** | 0.13*** | -0.03*** | 0.33*** | 1.00 | | | | | |
| (13) MTBV | 0.07*** | 0.01 | -0.08*** | -0.12*** | 0.03*** | 0.02* | -0.02** | -0.11*** | -0.10*** | -0.01 | -0.30*** | 0.04*** | 1.00 | | | | |
| (14) CASH | -0.02** | -0.01 | -0.03*** | -0.02** | -0.01 | 0.02*** | -0.02*** | -0.01 | -0.02** | 0.04*** | -0.06*** | -0.18*** | 0.06*** | 1.00 | | | |
| (15) INTANG | 0.02*** | -0.02** | 0.11*** | 0.12*** | 0.10*** | -0.02*** | -0.05*** | 0.07*** | 0.04*** | 0.08*** | 0.22*** | 0.11*** | -0.14*** | -0.04*** | 1.00 | | |
| (16) LIQ | 0.12*** | -0.04*** | -0.19*** | -0.18*** | -0.05*** | 0.01 | -0.10*** | -0.05*** | -0.11*** | 0.36*** | -0.32*** | -0.25*** | 0.17*** | 0.13*** | -0.21*** | 1.00 | |
| (17) FIRMAGE | 0.19*** | 0.09*** | 0.30*** | 0.18*** | 0.05*** | -0.04*** | 0.19*** | -0.02*** | 0.23*** | -0.09*** | 0.32*** | 0.30*** | -0.16*** | -0.04*** | 0.03*** | -0.19*** | 1.00 |

Variable definitions are detailed in Appendix 1.

* $p < 0.10$, ** $p < 0.05$, *** $p < 0.01$

Table 3: The effect of LIDIR on firm commitment to climate change

| | (1) | (2) | (3) | (4) |
|---|---|---|---|---|
| Variable | FCCC | FCCC | FCCC | FCCC |
| D_Lead | 0.111*** | 0.028** | - | - |
| | (8.08) | (2.16) | - | - |
| P_Lead1 | - | - | 0.178** | - |
| | - | - | (2.09) | - |
| P_Lead2 | - | - | - | 0.184* |
| | - | - | - | (1.66) |
| BoDsize | - | 0.011*** | 0.011*** | 0.011*** |
| | - | (5.51) | (5.77) | (5.81) |
| P_IndDir | - | 0.260*** | 0.267*** | 0.265*** |
| | - | (4.27) | (4.41) | (4.34) |
| P_IndWDir | - | 0.196*** | 0.198*** | 0.198*** |
| | - | (3.23) | (3.27) | (3.26) |
| FCEO | - | 0.041 | 0.043 | 0.041 |
| | - | (1.57) | (1.64) | (1.56) |
| CEOChair | - | -0.040*** | -0.039*** | -0.036*** |
| | - | (-3.12) | (-3.04) | (-2.78) |
| BoDmeet | - | 0.004*** | 0.004*** | 0.004*** |
| | - | (2.70) | (2.73) | (2.70) |
| ENVcomtte | - | 0.412*** | 0.412*** | 0.412*** |
| | - | (25.35) | (25.35) | (25.35) |
| CAPINT | - | -0.095*** | -0.095*** | -0.094*** |
| | - | (-2.63) | (-2.64) | (-2.59) |
| SIZE | - | 0.202*** | 0.202*** | 0.202*** |
| | - | (33.48) | (33.44) | (33.51) |
| ROA | - | 0.009 | 0.007 | 0.008 |
| | - | (0.23) | (0.18) | (0.21) |
| MTBV | - | 0.025*** | 0.025*** | 0.025*** |
| | - | (7.52) | (7.49) | (7.54) |
| CASH | - | -0.001* | -0.001* | -0.001* |
| | - | (-1.78) | (-1.75) | (-1.74) |
| INTANG | - | 0.235*** | 0.236*** | 0.235*** |
| | - | (7.85) | (7.87) | (7.85) |
| LIQ | - | 0.001 | 0.001 | 0.001 |
| | - | (0.51) | (0.49) | (0.50) |
| FIRMAGE | - | 0.012* | 0.012* | 0.012* |
| | - | (1.85) | (1.89) | (1.87) |
| Constant | -0.044 | -3.119*** | -3.133*** | -3.140*** |
| | (-0.28) | (-17.81) | (-17.92) | (-17.95) |
| Year_FE | Yes | Yes | Yes | Yes |
| Industry_FE | Yes | Yes | Yes | Yes |
| Observations | 12236 | 12236 | 12236 | 12236 |
| Adjusted $R^2$ | 0.128 | 0.406 | 0.406 | 0.406 |

Variable definitions are detailed in Appendix 1.

* $p < 0.10$, ** $p < 0.05$, *** $p < 0.01$

Table 4: Controlling for missing variabless

| | (1) FCCC | (2) FCCC | (3) FCCC | (4) FCCC |
|---|---|---|---|---|
| D_Lead | 0.024* | 0.032** | 0.024* | 0.026** |
| | (1.91) | (2.54) | (1.91) | (2.06) |
| BoDsize | 0.011*** | 0.010*** | 0.010*** | 0.009*** |
| | (5.95) | (5.15) | (4.95) | (4.94) |
| P_IndDir | 0.242*** | 0.222*** | 0.185*** | 0.151** |
| | (4.06) | (3.64) | (3.09) | (2.55) |
| P_IndWDir | 0.167*** | 0.198*** | 0.111* | 0.100* |
| | (2.79) | (3.23) | (1.87) | (1.68) |
| FCEO | 0.044* | 0.032 | 0.041 | 0.035 |
| | (1.71) | (1.22) | (1.56) | (1.37) |
| CEOChair | -0.033*** | -0.035*** | -0.035*** | -0.026** |
| | (-2.63) | (-2.70) | (-2.84) | (-2.08) |
| BoDmeet | 0.004*** | 0.004** | 0.004*** | 0.004** |
| | (2.80) | (2.33) | (2.75) | (2.53) |
| ENVcomtte | 0.353*** | 0.321*** | - | - |
| | (21.56) | (18.04) | - | - |
| CAPINT | -0.075** | -0.091** | -0.067* | -0.058* |
| | (-2.13) | (-2.53) | (-1.93) | (-1.71) |
| SIZE | 0.176*** | 0.193*** | 0.172*** | 0.148*** |
| | (29.90) | (31.75) | (28.46) | (24.92) |
| ROA | 0.028 | 0.020 | -0.012 | 0.015 |
| | (0.73) | (0.50) | (-0.31) | (0.41) |
| MTBV | 0.021*** | 0.026*** | 0.023*** | 0.021*** |
| | (6.38) | (7.67) | (7.29) | (6.52) |
| CASH | -0.001* | -0.001 | -0.001 | -0.001 |
| | (-1.85) | (-0.37) | (-1.49) | (-0.37) |
| INTANG | 0.209*** | 0.221*** | 0.197*** | 0.163*** |
| | (7.02) | (7.30) | (6.73) | (5.52) |
| LIQ | 0.002 | 0.001 | 0.001 | 0.001 |
| | (0.90) | (0.19) | (0.45) | (0.42) |
| FIRMAGE | 0.003 | 0.008 | 0.006 | 0.003 |
| | (0.53) | (1.28) | (0.99) | (0.53) |
| EcoInn_score | 0.005*** | - | - | 0.004*** |
| | (17.38) | - | - | (14.40) |
| ENV_train | - | 0.196*** | - | 0.149*** |
| | - | (11.86) | - | (9.37) |
| Climate_gov | - | - | 0.279*** | 0.217*** |
| | - | - | (32.33) | (23.02) |
| Constant | -2.714*** | -2.971*** | -2.570*** | -2.187*** |
| | (-16.09) | (-17.22) | (-15.10) | (-13.32) |
| Year_FE | Yes | Yes | Yes | Yes |
| Industry_FE | Yes | Yes | Yes | Yes |
| Observations | 12191 | 12021 | 12236 | 12021 |
| Adjusted $R^2$ | 0.428 | 0.417 | 0.432 | 0.455 |

Variable definitions are detailed in Appendix 1.
* $p < 0.10$, ** $p < 0.05$, *** $p < 0.01$

Table 5: Pre-SDGs period versus SDGs period

| Variable | (1) Pre-SDGs (2002-2014) | (2) SDGs (2015-2019) |
|---|---|---|
| D_Lead | 0.033** | 0.050*** |
| | (2.14) | (3.07) |
| BoDsize | 0.013*** | 0.008*** |
| | (3.68) | (3.51) |
| P_IndDir | 0.385*** | 0.140* |
| | (4.29) | (1.68) |
| P_IndWDir | 0.055* | 0.434*** |
| | (1.71) | (4.29) |
| FCEO | 0.014 | 0.086** |
| | (0.42) | (2.08) |
| CEOChair | -0.054*** | -0.005 |
| | (-2.79) | (-0.30) |
| BoDmeet | 0.006*** | 0.002* |
| | (2.84) | (1.88) |
| ENVcomtte | 0.426*** | 0.386*** |
| | (16.44) | (19.22) |
| CAPINT | -0.165*** | -0.071 |
| | (-3.47) | (-1.19) |
| SIZE | 0.204*** | 0.192*** |
| | (22.78) | (24.76) |
| ROA | -0.088* | 0.163** |
| | (-1.68) | (2.03) |
| MTBV | 0.028*** | 0.018*** |
| | (6.93) | (2.97) |
| CASH | 0.001 | -0.004*** |
| | (1.48) | (-6.76) |
| INTANG | 0.243*** | 0.199*** |
| | (5.83) | (4.70) |
| LIQ | 0.001 | 0.001 |
| | (0.06) | (0.27) |
| FIRMAGE | 0.008 | 0.020** |
| | (0.97) | (2.01) |
| Constant | -2.783*** | -3.172*** |
| | (-11.75) | (-21.37) |
| Year_FE | Yes | Yes |
| Industry_FE | Yes | Yes |
| Observations | 5806 | 6430 |
| Adjusted $R^2$ | 0.408 | 0.416 |

Variable definitions are detailed in Appendix 1.
* $p < 0.10$, ** $p < 0.05$, *** $p < 0.01$

Table 6: Propensity score matching
Panel A: Pre-match and post-match regressions

| | (1) | (2) | (3) |
|---|---|---|---|
| | Pre-match probit | Post-match probit | Post-match OLS |
| Variable | D_Lead | D_Lead | FCCC |
| D_Lead | - | - | 0.087*** |
| | - | - | (5.91) |
| BoDsize | 0.049*** | -0.005 | 0.008** |
| | (10.35) | (-1.03) | (2.30) |
| P_IndDir | 2.385*** | -0.008 | 0.087** |
| | (13.09) | (-0.04) | (1.96) |
| P_IndWDir | 0.839*** | -0.231 | 0.829*** |
| | (5.33) | (-1.36) | (10.45) |
| FCEO | 0.027 | 0.034 | 0.064 |
| | (0.39) | (0.40) | (1.57) |
| CEOChair | 1.503*** | 0.021 | -0.123*** |
| | (43.80) | (0.43) | (-4.90) |
| BoDmeet | 0.001 | 0.002 | 0.003** |
| | (0.27) | (0.40) | (2.37) |
| ENVcomtte | -0.109*** | -0.028 | 0.534*** |
| | (-3.28) | (-0.78) | (25.61) |
| CAPINT | 0.357*** | 0.050 | -0.035* |
| | (3.46) | (0.49) | (-1.80) |
| SIZE | -0.001 | 0.004 | 0.165*** |
| | (-0.08) | (0.31) | (22.71) |
| ROA | -0.211 | -0.186 | -0.199*** |
| | (-1.61) | (-1.26) | (-3.78) |
| MTBV | 0.027*** | -0.004 | 0.022*** |
| | (2.88) | (-0.35) | (5.08) |
| CASH | 0.001* | -0.000 | -0.001 |
| | (1.82) | (-1.00) | (-0.56) |
| INTANG | -0.192** | -0.003 | 0.211*** |
| | (-2.53) | (-0.05) | (5.74) |
| LIQ | 0.007 | -0.007 | 0.002 |
| | (0.97) | (-0.84) | (0.64) |
| FIRMAGE | -0.002 | 0.007 | 0.016* |
| | (-0.13) | (0.33) | (1.76) |
| Constant | -5.755*** | 0.103 | -2.194*** |
| | (-18.78) | (0.40) | (-17.60) |
| Year_FE | Yes | Yes | Yes |
| Industry_FE | Yes | Yes | Yes |
| Observations | 12236 | 7070 | 7070 |
| Adjusted $R^2$ | - | - | 0.309 |
| Pseudo $R^2$ | 0.237 | 0.002 | - |

Panel B: Pre-match and post-matched sample testing

| Variables | Pre-match sample | | | Post-match sample | | |
|---|---|---|---|---|---|---|
| | Control group D_Lead = 0 N=7265 Mean | Treatment group D_Lead = 1 N=4826 Mean | Mean differences | Control group D_Lead = 0 N= 3535 Mean | Treatment group D_Lead = 1 N= 3535 Mean | Mean differences |
| BoDsize | 10.632 | 11.606 | -0.973*** | 11.302 | 11.275 | 0.027 |
| P_IndDir | 0.809 | 0.845 | -0.036*** | 0.834 | 0.832 | 0.002 |
| P_IndWDir | 0.120 | 0.140 | -0.020*** | 0.125 | 0.122 | 0.003 |
| FCEO | 0.042 | 0.039 | 0.033 | 0.033 | 0.032 | 0.001 |
| CEOChair | 0.491 | 0.910 | -0.418*** | 0.883 | 0.886 | -0.003 |
| BoDmeet | 7.870 | 7.645 | 0.225*** | 7.644 | 7.687 | -0.043 |
| ENVcomtte | 0.277 | 0.344 | -0.067*** | 0.310 | 0.292 | 0.018 |
| CAPINT | 0.685 | 0.676 | 0.009*** | 0.667 | 0.670 | -0.003 |
| SIZE | 14.936 | 15.230 | -0.294*** | 15.240 | 15.205 | 0.035 |
| ROA | 0.074 | 0.086 | -0.012*** | 0.097 | 0.095 | 0.002 |
| MTBV | 2.365 | 2.407 | -0.042 | 2.340 | 2.314 | -0.026 |
| CASH | 3.666 | 2.877 | 0.789 | 2.352 | 2.286 | 0.066 |
| INTANG | 0.314 | 0.305 | 0.008** | 0.307 | 0.305 | 0.002 |
| LIQ | 2.621 | 2.390 | 0.230*** | 2.307 | 2.317 | -0.010 |
| FIRMAGE | 2.711 | 2.890 | -0.179*** | 2.900 | 2.879 | 0.021 |

Variable definitions are detailed in Appendix 1.

* $p < 0.10$, ** $p < 0.05$, *** $p < 0.01$

Table 7: Heckman two step

| Variable | (1)<br>D_Lead | (2)<br>FCCC |
|---|---|---|
| D_Lead | - | 0.026** |
| | - | (2.03) |
| MILLS | - | 0.194*** |
| | - | (3.05) |
| BoDsize | 0.049*** | 0.014*** |
| | (10.35) | (4.03) |
| P_IndDir | 2.385*** | 0.530** |
| | (13.09) | (2.00) |
| P_IndWDir | 0.839*** | 0.403* |
| | (5.33) | (1.95) |
| FCEO | 0.027 | 0.054* |
| | (0.39) | (1.81) |
| CEOChair | 1.503*** | -0.161* |
| | (43.80) | (-1.84) |
| BoDmeet | 0.001 | 0.004*** |
| | (0.27) | (2.68) |
| ENVcomtte | -0.109*** | 0.418*** |
| | (-3.28) | (27.76) |
| CAPINT | 0.357*** | -0.076** |
| | (3.46) | (-2.52) |
| SIZE | -0.001 | 0.199*** |
| | (-0.08) | (33.27) |
| ROA | -0.211 | -0.064 |
| | (-1.61) | (-0.74) |
| MTBV | 0.027*** | 0.029*** |
| | (2.88) | (5.31) |
| CASH | 0.001* | -0.001* |
| | (1.82) | (-1.71) |
| INTANG | -0.192** | 0.257*** |
| | (-2.53) | (6.85) |
| LIQ | 0.007 | 0.001 |
| | (0.97) | (0.10) |
| FIRMAGE | -0.002 | 0.011 |
| | (-0.13) | (1.63) |
| Constant | -5.755*** | -3.747*** |
| | (-18.78) | (-6.08) |
| Year_FE | Yes | Yes |
| Industry_FE | Yes | Yes |
| Observations | 12236 | 12236 |
| Adjusted $R^2$ | - | 0.406 |
| Pseudo $R^2$ | 0.237 | - |

Variable definitions are detailed in Appendix 1.
* $p < 0.10$, ** $p < 0.05$, *** $p < 0.01$

Table 8: Instrumental variable (IV) method

| | 2SLS | | LIML | | GMM |
|---|---|---|---|---|---|
| | (1) | (2) | (3) | (4) | (5) |
| Variable | First Stage | Second Stage | First Stage | Second Stage | |
| D_Lead | - | 0.055*** | - | 0.052*** | 0.048** |
| | - | (2.82) | - | (2.77) | (2.44) |
| $D\_Lead_{t-1}$ | 2.601*** | - | 2.601*** | - | - |
| | (59.95) | - | (59.95) | - | - |
| BoDsize | 0.045*** | 0.010*** | 0.045*** | 0.002* | 0.009*** |
| | (6.90) | (4.27) | (6.90) | (1.92) | (3.89) |
| P_IndDir | 1.408*** | 0.338*** | 1.408*** | 0.026 | 0.366*** |
| | (5.02) | (4.36) | (5.02) | (0.33) | (4.71) |
| P_IndWDir | 0.262 | 0.276*** | 0.262 | 0.958*** | 0.257*** |
| | (1.04) | (3.69) | (1.04) | (12.92) | (3.52) |
| FCEO | -0.067 | 0.048 | -0.067 | 0.071** | 0.053 |
| | (-0.63) | (1.51) | (-0.63) | (2.16) | (1.59) |
| CEOChair | 0.959*** | -0.051*** | 0.959*** | -0.124*** | -0.040** |
| | (18.27) | (-3.19) | (18.27) | (-7.42) | (-2.43) |
| BoDmeet | -0.018*** | 0.004** | -0.018*** | 0.003* | 0.003* |
| | (-2.94) | (2.18) | (-2.94) | (1.71) | (1.79) |
| ENVcomtte | -0.075 | 0.412*** | -0.075 | 0.501*** | 0.456*** |
| | (-1.49) | (23.14) | (-1.49) | (27.94) | (25.89) |
| CAPINT | 0.219 | -0.080* | 0.219 | -0.088* | -0.092** |
| | (1.33) | (-1.68) | (1.33) | (-1.74) | (-2.06) |
| SIZE | -0.009 | 0.229*** | -0.009 | 0.198*** | 0.220*** |
| | (-0.45) | (31.50) | (-0.45) | (26.98) | (32.17) |
| ROA | 0.142 | 0.047 | 0.142 | -0.218*** | 0.075 |
| | (0.49) | (0.87) | (0.49) | (-3.94) | (1.45) |
| MTBV | 0.026* | 0.028*** | 0.026* | 0.033*** | 0.028*** |
| | (1.65) | (6.46) | (1.65) | (7.25) | (6.74) |
| CASH | 0.001 | -0.001* | 0.001 | -0.001* | -0.001* |
| | (0.17) | (-1.86) | (0.17) | (-1.88) | (-1.80) |
| INTANG | 0.051 | 0.264*** | 0.051 | 0.167*** | 0.257*** |
| | (0.50) | (7.09) | (0.50) | (4.32) | (8.03) |
| LIQ | -0.007 | 0.003 | -0.007 | 0.003 | 0.002 |
| | (-0.049) | (0.84) | (-0.049) | (0.68) | (0.51) |
| FIRMAGE | -0.084*** | 0.013 | -0.084*** | 0.016 | 0.025*** |
| | (-2.70) | (1.41) | (-2.70) | (1.61) | (2.77) |
| LFCCC | - | - | - | - | 0.861*** |
| | - | - | - | - | (44.96) |
| Constant | -3.644*** | -2.703*** | -3.644*** | -2.292*** | -3.104*** |
| | (-9.35) | (-12.81) | (-9.35) | (-9.73) | (-26.56) |
| Year_FE | Yes | Yes | Yes | Yes | Yes |
| Industry_FE | Yes | Yes | Yes | Yes | Yes |
| Observations | 9223 | 9322 | 9223 | 9322 | 9322 |
| Adjusted $R^2$ | - | 0.410 | - | 0.353 | - |
| Pseudo R2 | 0.626 | - | 0.626 | - | - |
| AR1 | - | - | - | - | -10.78*** |
| AR2 | - | - | - | - | 0.84 |

Variable definitions are detailed in Appendix 1.

* $p < 0.10$, ** $p < 0.05$, *** $p < 0.01$

Table 9: Firms with CEO chairs versus non-CEO chairs

| Variable | (1) CEOChair | (2) non-CEOChair |
|---|---|---|
| D_Lead | 0.096*** | 0.020* |
| | (2.76) | (1.85) |
| BoDsize | 0.007* | 0.012*** |
| | (1.79) | (5.20) |
| P_IndDir | 0.529*** | 0.129** |
| | (5.55) | (2.49) |
| P_IndWDir | 0.325*** | 0.041 |
| | (4.22) | (0.41) |
| FCEO | 0.063* | 0.004 |
| | (1.74) | (0.11) |
| BoDmeet | 0.006*** | 0.002** |
| | (2.65) | (2.01) |
| ENVcomtte | 0.395*** | 0.415*** |
| | (13.70) | (21.20) |
| CAPINT | -0.134** | -0.166** |
| | (-2.13) | (-2.49) |
| SIZE | 0.201*** | 0.201*** |
| | (18.99) | (27.29) |
| ROA | 0.041 | 0.066 |
| | (0.70) | (1.18) |
| MTBV | 0.032*** | 0.021*** |
| | (5.89) | (4.91) |
| CASH | -0.001 | -0.001 |
| | (-1.07) | (-1.44) |
| INTANG | 0.226*** | 0.226*** |
| | (4.79) | (5.77) |
| LIQ | 0.002 | 0.007** |
| | (1.01) | (2.02) |
| FIRMAGE | 0.023** | 0.001 |
| | (2.53) | (0.17) |
| Constant | -2.983*** | -3.174*** |
| | (-12.24) | (-14.77) |
| Year_FE | Yes | Yes |
| Industry_FE | Yes | Yes |
| Observations | 7990 | 4246 |
| Adjusted $R^2$ | 0.412 | 0.413 |

Variable definitions are detailed in Appendix 1.
* $p < 0.10$, ** $p < 0.05$, *** $p < 0.01$

Table 10: LIDIR, Climate change commitment and ESG performance

| Variable | (1) ESGscore | (2) ENVscore | (3) SOCscore | (4) GOVscore |
|---|---|---|---|---|
| FCCC | 0.167 | 0.290 | 0.148 | 0.099 |
| | (1.40) | (1.38) | (1.46) | (1.28) |
| D_Lead | 0.049*** | 0.099*** | 0.093*** | 0.108*** |
| | (6.20) | (3.32) | (3.92) | (7.73) |
| FCCC×D_Lead | 0.040*** | 0.049** | 0.043*** | 0.046*** |
| | (5.44) | (2.50) | (4.90) | (4.38) |
| BoDsize | 0.002** | 0.003 | 0.007*** | 0.011*** |
| | (2.27) | (0.96) | (4.07) | (5.33) |
| P_IndDir | 0.844*** | 0.335** | 0.292*** | 1.739*** |
| | (17.14) | (2.44) | (4.97) | (23.65) |
| P_IndWDir | 0.695*** | 0.924*** | 0.466*** | 0.921*** |
| | (16.75) | (8.13) | (8.96) | (15.87) |
| FCEO | 0.064*** | 0.026 | 0.039** | 0.098*** |
| | (4.34) | (0.60) | (2.06) | (4.53) |
| CEOChair | -0.104*** | 0.023 | -0.004 | -0.267*** |
| | (-12.21) | (0.98) | (-0.35) | (-21.22) |
| BoDmeet | 0.002* | 0.001 | 0.002** | 0.002 |
| | (1.80) | (0.16) | (2.00) | (1.59) |
| ENVcomtte | 0.284*** | 0.578*** | 0.293*** | 0.130*** |
| | (32.17) | (27.73) | (27.87) | (10.51) |
| CAPINT | -0.130*** | -0.227*** | -0.166*** | -0.020 |
| | (-5.09) | (-3.13) | (-5.05) | (-0.57) |
| SIZE | 0.100*** | 0.238*** | 0.121*** | 0.033*** |
| | (26.04) | (26.26) | (26.29) | (5.98) |
| ROA | 0.055* | -0.066 | -0.126*** | 0.362*** |
| | (1.75) | (-0.44) | (-3.18) | (6.93) |
| MTBV | 0.011*** | 0.026*** | 0.025*** | -0.011** |
| | (3.97) | (2.77) | (7.89) | (-2.44) |
| CASH | 0.001*** | 0.004 | 0.001*** | 0.001* |
| | (4.08) | (0.71) | (4.52) | (1.82) |
| INTANG | 0.142*** | 0.224*** | 0.122*** | 0.199*** |
| | (6.64) | (3.89) | (4.45) | (6.50) |
| LIQ | -0.003 | -0.004 | -0.002 | -0.001 |
| | (-1.21) | (-0.61) | (-0.90) | (-0.07) |
| FIRMAGE | 0.086*** | 0.072*** | 0.008 | 0.194*** |
| | (18.30) | (5.64) | (1.45) | (26.81) |
| Constant | 0.612*** | -1.243*** | 0.742*** | 1.261*** |
| | (5.43) | (-3.83) | (5.92) | (6.94) |
| Year_FE | Yes | Yes | Yes | Yes |
| Industry_FE | Yes | Yes | Yes | Yes |
| Observations | 12236 | 12236 | 12236 | 12236 |
| Adjusted $R^2$ | 0.534 | 0.435 | 0.412 | 0.325 |

Variable definitions are detailed in Appendix 1.

* $p < 0.10$, ** $p < 0.05$, *** $p < 0.01$

Appendix 1: Variable definitions.

| Variable | Definition |
|---|---|
| FCCC | A firm's commitment to climate change index is calculated as a composite score by adding the four components of climate commitment: (i) a dummy variable coded as 1 if a firm has a policy that supports SDG 13 on climate action, and 0 otherwise, (ii) a dummy variable coded as 1 if a firm has a policy that recognises the commercial risks and opportunities from climate change, and 0 otherwise, (iii) a dummy variable coded as 1 if a firm discloses Scope 3 $CO_2$ emissions, and 0 otherwise, and (iv) a dummy variable coded as 1 if a firm sets emissions reduction target, and 0 otherwise. |
| D_Lead | A dummy variable coded as 1 for each firm-year observation with the board role capturing any of the LIDIR titles - lead independent trustee, lead independent director, facilitating director, lead outside director, lead director, presiding director, lead trustee, and presiding trustee, and 0 otherwise. |
| BoDsize | The number of directors serving on the board |
| P_IndDir | The number of independent directors divided by the number of directors serving on the board. |
| P_IndWDir | The number of independent female directors divided by the number of directors serving on the board. |
| FCEO | A dummy variable coded as 1 for each firm-year observation with a female CEO, and 0 otherwise. |
| CEOChair | A dummy variable coded as 1 for each firm-year observation with the CEO and board chair positions consolidated, and 0 otherwise. |
| BoDmeet | The number of board meetings. |
| ENVcomtte | A dummy variable coded as 1 for each firm-year observation with the presence of environmental committee, and 0 otherwise. |
| CAPINT | A firm's capital divided total sales. |
| SIZE | The natural logarithm of the total assets. |
| ROA | Net income divided by total assets. |
| MTBV | A firm's market value divided by the book value of common equity. |
| CASH | A firm's cash flow from operations divided by total sales. |
| INTANG | A firm's total intangible assets divided total assets. |
| LIQUIDITY | A firm's current assets divided by current liabilities. |
| FIRMAGE | The natural logarithm of the number of years since a firm's incorporation. |

Appendix 2: Year distribution of FCCC

| | *N* | Mean | SD |
|---|---|---|---|
| 2002 | 185 | 0.038 | 0.191 |
| 2003 | 208 | 0.067 | 0.251 |
| 2004 | 271 | 0.059 | 0.236 |
| 2005 | 371 | 0.124 | 0.338 |
| 2006 | 374 | 0.128 | 0.351 |
| 2007 | 396 | 0.275 | 0.506 |
| 2008 | 497 | 0.316 | 0.556 |
| 2009 | 571 | 0.466 | 0.718 |
| 2010 | 601 | 0.551 | 0.769 |
| 2011 | 598 | 0.600 | 0.787 |
| 2012 | 583 | 0.626 | 0.798 |
| 2013 | 589 | 0.586 | 0.736 |
| 2014 | 562 | 0.544 | 0.718 |
| 2015 | 891 | 0.371 | 0.643 |
| 2016 | 1287 | 0.326 | 0.605 |
| 2017 | 1375 | 0.437 | 0.786 |
| 2018 | 1425 | 0.510 | 0.854 |
| 2019 | 1452 | 0.668 | 1.042 |
| Total | 12236 | 0.443 | 0.758 |