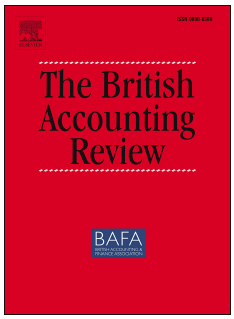

Climate Governance Effects On Carbon Disclosure And Performance

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CLIMATE GOVERNANCE EFFECTS ON CARBON DISCLOSURE AND PERFORMANCE

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CLIMATE GOVERNANCE EFFECTS ON CARBON DISCLOSURE AND PERFORMANCE

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Abstract

Integration of carbon oversight into board structures and processes has the potential to improve carbon performance and demonstrate accountability to stakeholders. However, it is not clear how climate governance affects carbon disclosure. Contributing to two strands of the literature, sustainability and governance issues, this paper examines the combined impact of climate governance on carbon disclosure. We find climate governance is associated with alignment between carbon disclosure and carbon performance. The results suggest that climate governance also reduces over-acclaiming of good performance via extensive disclosure, and low-polluters disclose more to differentiate themselves. Our findings highlight the importance of the frequency of reporting to the board and time horizon of carbon reporting for improving carbon disclosure and carbon performance. In contrast to traditional governance mechanisms, our results suggest climate governance better reflects firms' commitment to addressing sustainability issues and transparent reporting.

Keywords: climate governance; climate change; disclosure; sustainability; social impact.

1. Introduction

Companies are increasingly expected to be accountable not only for their financial performance but also for their social impact. There is a long history of developments in non-financial reporting (Stolowy & Paugam, 2018), especially the promotion of sustainability reporting (Unerman, Bebbington, & O'Dwyer, 2010; Bebbington & Larrinaga, 2014; Al-Shaer & Zaman, 2018) and integrated reporting (de Villiers, Venter, & Hsiao, 2017; Zhou, Simnett, & Green., 2017; Rinaldi, Unerman, & de Villiers, 2018). A more recent and prominent issue of concern to both management and stakeholders is climate change (IPCC, 2018). There is growing pressure on firms to report on their carbon emissions and to be accountable for social impact (Bui & de Villiers, 2017a; Arena, Azzone, & Mapelli, 2018). Carbon disclosure is an important channel through which firms can demonstrate their oversight and accountability to stakeholders (Hollindale, Kent, Routledge, & Chapple, 2019). The relationship between carbon disclosure and carbon performance may be affected by the strength of climate governance.[1] This paper examines (i) the combined impact of climate governance on carbon disclosure and (ii) the effect of climate governance on the carbon disclosure and carbon performance relationship.

The relationship between carbon disclosure and performance is complex and may be affected by a multiplicity of factors. First, theoretically the relationship between carbon disclosure and underlying carbon performance may be conceptualised from two contrasting perspectives: signalling theory and legitimacy theory. Signalling theory suggests that firms that have strong carbon performance are likely to be driven by a desire to highlight their good performance to stakeholders and thus report more extensively on climate change issues. Prior research has found that firms with more extensive carbon disclosure are more

[1] Climate governance refers to the "purposeful mechanisms and measures aimed at steering (organisational) social systems towards preventing, mitigating or adapting to the risks posed by climate change" (Jagers & Stripple, 2003: 388).

likely to benefit from higher financial returns including market valuation and lower cost of capital (Toms, 2002; Clarkson, Li, Richardson, & Vasvari, 2008; Luo & Tang, 2014). In contrast, legitimacy theory posits that firms are likely to use disclosure to greenwash and obfuscate poor environmental performance (Deegan & Gordon, 1996; Patten, 2002; Michelon, Patten, & Romi, 2019). Existing research, however, neither confirms nor refutes either theory (see section 2.1). Second, prior studies provide evidence on the effect of corporate governance characteristics, such as board diversity, board independence and board size, on sustainability reporting and stakeholder engagement (McWilliams, Siegel, & Wright, 2006; Ntim & Soobaroyen, 2013). In a similar manner, corporate governance can affect the carbon disclosure-performance relationship (see section 2.2). Third, organisational and industry-related factors such as emissions intensity, environmental sensitivity, and perceived litigation risks can influence carbon performance and disclosure. Fourth, given the heightened expectations regarding accountability for carbon, voluntary adoption of governance measures specifically relating to carbon is likely to affect carbon disclosure. Additionally, broader developments in non-financial reporting, including sustainability and integrated reporting, could also be a factor.[2]

This paper empirically examines the impact of climate governance on carbon disclosure while being attentive to the traditional governance mechanisms, organisational and industry-related factors that may affect the relationship.[3] Our study is based on a sample of S&P 500 firms which are subject to institutional and stakeholder pressures to demonstrate leadership and be accountable for their carbon emissions. We find that, in order

[2] For instance, integrated reporting, as with other forms of reporting, might reflect global reporting templates and has to be examined in the context of its particular development (de Villiers & Alexander, 2014).

[3] Though the focus of our paper is not on the benefits of integrated reporting, we recognise a rapid spread in the adoption of integrated reporting (Serafeim, 2015; de Villiers et al., 2017; Zhou et al., 2017). Integrated reporting among others, has been promoted as a credible form of sustainability reporting, helping businesses to take more sustainable decisions, though its ability to achieve this has been criticised (Thomson, 2015). Our paper does not extend to directly comparing firms' carbon disclosure with other forms of non-financial reporting such as integrated reporting. We believe such an investigation is important and needs to be carefully designed. As de Villiers et al. (2017) observe, there are significant challenges in employing an accurate measurement of integrated reporting adoption and integrated reporting quality using large databases such as Thomson Reuters or KLD and matching them with sustainability reporting.

to reduce information asymmetry and differentiate themselves from their peers, good carbon performers disclose more. We also find evidence which suggests that climate governance reduces managerial discretion over disclosure and strengthens the link between carbon disclosure and carbon performance. In contrast to prior literature, we do not find any significant relationship between traditional corporate governance mechanisms (such as board diversity, independence, size) and carbon disclosure. But we find climate governance, particularly the frequency of carbon reporting to the board and the time horizon of carbon information, is associated with carbon disclosure.

Our paper contributes to the literature in three ways. First, it contributes to the emerging literature on carbon disclosure and carbon performance relationship by focusing on one defined aspect of environmental performance, i.e. climate change issues. Secondly, our study is the first to document the impact of climate governance on disclosure behaviour. Few studies have explicitly examined governance characteristics that are dedicated to climate governance such as the level of management responsibility for climate change issues, frequency and time horizon of risk reporting at the board level, and the presence of executive incentives linked to carbon performance.[4] As these mechanisms work in conjunction to affect policies and management decisions, there is a need to examine their combined impact on carbon disclosure. Thirdly, we examine the role played by traditional corporate governance in the specific context of carbon disclosure. As corporate governance is expected to be responsive to stakeholder concerns about climate change issues (Peters & Romi, 2014), our research contributes insights to better understand whether governance mechanisms can promote carbon disclosure and carbon performance.

Our findings have important implications. Stakeholders and regulators are likely to be interested in learning about the role of climate governance in facilitating carbon

[4] For instance, Liao et al. (2015) and Peters and Romi (2014) examine the presence of an environmental board committee and likelihood of carbon disclosure.

disclosure and in enabling reporting of underlying carbon performance. Investors and stakeholders interested in more in-depth understanding of a firm's carbon performance need to critically examine the embeddedness of climate change issues into governance mechanisms and to be cautious about relying on traditional governance mechanisms; that is, they may benefit from paying greater attention to climate governance. Particularly, investors seeking more transparent disclosure to inform their decisions may need to exert pressure to get climate change issues integrated into board processes. Regulators wishing to encourage more environmentally responsible behaviour should note that disclosure alone may not result in better carbon performance or carbon mitigation, and regulatory initiatives may be necessary to ensure climate change issues are well integrated into board processes. Our paper provides important insights into the potential role of climate governance. However, caution is needed in generalising from our study, especially given its exploratory nature, as well as the sample and time period examined.

The rest of the paper is organized as follows. Section 2 reviews the prior literature and develops the hypotheses. In section 3 we outline the research method. The empirical findings are reported in section 4. Finally, section 5 concludes the paper with a discussion of our contributions and suggestion for future research.

2. Literature Review and Hypotheses Development

2.1 Carbon disclosure and performance

Two well-established theories explain the association between carbon disclosure and carbon performance: signalling theory and legitimacy theory. According to signalling theory, firms aim to differentiate themselves by signalling their superior carbon performance to stakeholders and thereby gain a competitive advantage (Clarkson et al., 2008). In contrast, to hide their underlying performance or to avoid responsibility for poor performance, firms with poor performance may exacerbate information asymmetry by reducing the level of

carbon disclosure (Cho, Patten, & Roberts, 2006). Consistent with a signalling perspective, some studies find a positive relationship between environmental disclosure and environmental performance. Al-Tuwaijri, Christensen, & Hughes (2004) find good environmental performance is associated with more extensive disclosure of quantifiable pollution-related measures. Similarly, Clarkson et al. (2008) and Iatridis (2013) find a positive association between discretionary disclosure and environmental performance. Luo and Tang (2014) suggest that firms' voluntary carbon disclosure is indicative of their underlying carbon performance. This is echoed by Qian and Schaltegger (2017) who find a positive association between carbon disclosure change and subsequent change in performance suggesting an outside-in effect whereby disclosure motivates firms to improve their carbon performance.

Legitimacy theory suggests a negative relationship between carbon disclosure and carbon performance. Firms have a social contract with stakeholders and the wider society. To gain societal acceptance, it is pertinent that firms comply with societal norms and expectations. However, because the underlying interest of firms may be profit-maximisation rather than environmental protection, compliance may be symbolic rather than substantive. Firms may thus decouple their compliance with (certain) societal norms while keeping their core operations intact (Perego & Kolk, 2012). High emissions-intensive firms, for example those in the resources or energy sectors, may continue to emit high emissions due to the nature of their core business. However, because firms need to demonstrate their responsibility to stakeholders, they may choose to merely increase disclosure of soft and non-quantifiable information to explain their carbon reduction initiatives without substantiating the information with hard indicators of actual carbon mitigation (García-Meca & Sánchez-Ballesta, 2010). In doing so, firms can portray themselves as environmentally responsible whilst continuing their emissions-intensive operations. In some cases, disclosure may be used to justify or hide increased carbon emissions, thereby

manipulating or negotiating public pressures and understanding of climate change issues (de Villiers & van Staden, 2006).[5]

The relationship between carbon disclosure and carbon performance is complex. A desire to signal organisational accountabilty, as opposed to masking the true (poor) performance, as well as governance mechanisms (both traditional (see section 2.2) and those specific to oversight of climate change issues (see section 2.3)) can affect the relationship between carbon disclosure and carbon performance. Signalling theory suggests a positive relationship, whereas when firms are driven by legitimacy concerns the relationship is expected to be negative. While noting that the underlying motivation may be theoretically different and complex, we expect a positive association between carbon disclosure and carbon performance because certain firms, in our case S&P 500 firms, are under significant public scrutiny, and their ability to disguise bad performance through extensive disclosure is lower. Hence, consistent with signalling theory, we expect firms to use disclosure to differentiate themselves. Our first hypothesis is:

H1: There is a positive association between carbon disclosure and carbon performance.

2.2 Corporate governance and carbon disclosure

Good corporate governance is aimed at understanding and addressing multiple stakeholder demands and expectations. Stakeholder engagement provides an essential channel to achieve such understanding (Unerman & Bennett, 2004). From a signalling perspective, sustainability reporting can signal the quality of corporate governance (Bozzolan, Fabrizi, Mallin, & Michelon, 2015) and demonstrate firms' responsiveness to the needs of different stakeholders (Michelon & Parbonetti, 2012). More extensive information and good

[5] Consistent with legitimacy theory, some studies do not find a relationship between environmental disclosure and environmental performance. Alrazi, de Villiers, and van Staden (2016) find no significant relationship. Cho et al. (2006) find disclosure and political spending are proactive tactics firms use to respond to public policy pressures and thereby avoid their environmental responsibilities. In a related study, Cho, Roberts, and Patten (2010) find poor environmental performers employ more optimistic language to attribute success to internal efforts and use more uncertainty to avoid responsibility for poor performance.

sustainabiltiy practices can help increase trust and reduce transaction costs when dealing with stakeholders (Ntim & Soobaroyen, 2013). Additionally, through their contacts and connections, boards can help firms manage external dependencies and receive important external resources and reduce uncertainty (Yousf, Zakaria, & Thankom, 2018). Hence, disclosure can be used by boards to reduce information asymmetry and enhance access to important resources.

Studies examining boards of directors suggest that better-governed firms tend to adopt sustainability practices and the relationship between sustainability and financial performance is stronger under good corporate governance (Kolk & Pinkse, 2010; Jo & Harjoto, 2011; Liao, Luo, & Tang, 2015; Al-Shaer & Zaman, 2019). Using a sample of US FORTUNE Global 250 firms, Kolk and Pinkse (2010) find a majority of their sample firms provide a separate section on corporate governance as part of sustainability reporting and link corporate governance and sustainability issues. Jo and Harjoto (2011) similarly find firms' choice to engage with sustainability issues is positively associated with corporate governance mechanisms, including board leadership and board independence. Liao et al. (2015) find a board with more independent directors or with an environmental committee is more likely to pursue higher disclosure transparency. Similarly, Al-Shaer and Zaman (2016) find that gender-diverse boards are associated with higher sustainability reporting quality.

Based on the prior literature, we posit a positive association between corporate governance and carbon disclosure. Our second hypothesis is thus:

H2: There is a positive association between corporate governance and carbon disclosure.

2.3 Climate governance and carbon disclosure

Current conceptualisation of corporate governance in extant studies may not capture the extent to which a firm's board is committed to sustainability issues. Indeed, studies that examine the presence of environmental committees as part of the board structure have

found these committees have a positive impact on sustainability disclosure (Peters & Romi, 2014; Liao et al., 2015). The integration of climate change issues at the board level is a strong indicator of a firm's commitment to addressing climate change. One indicator of this commitment is whether boards monitor carbon emissions and carbon performance (Prado-Lorenzo & Garcia-Sanchez, 2010), for example, through having a sub-committee or a director responsible for climate change issues or providing incentives to directors and management for carbon mitigation (Ioannou, Xin Li, & Serafeim, 2016).

Hence, similar to the arguments made earlier in section 2.2, we posit that strong integration of climate change issues in governance can have a positive impact on carbon disclosure. Firms with strong climate governance are more likely to be interested in climate change issues and hence use disclosure as a channel to communicate and engage with relevant stakeholders. In addition, firms with environmental commitment are likely to use disclosure to differentiate themselves from peers and achieve a green image or competitive advantage.

Carbon disclosure and carbon performance is more aligned/coupled under high carbon performance conditions because high performers, under the guidance of boards, disclose more to signal strong performance and differentiate themselves (Qian & Schaltegger, 2017). Prior studies using communication theory (Reiss & Tedeschi, 1981; Hooghiemstra, 2000) suggest that by using disclosure, management tends to acclaim and maximise its personal attribution to good performance, while justifying and avoiding responsibility associated with poor performance. Therefore, since boards oversee disclosure policies, it can be expected that management's ability to provide extensive disclosure to acclaim its personal contribution to the firm's good carbon performance would be reduced in firms with strong climate governance (Alrazi, de Villers, & van Staaden, 2016). Also, in an attempt to protect firms' legitimacy, boards may use climate governance to mitigate management's tendency to reduce disclosure to hide poor performance and avoid

accountability (de Villiers & van Staden, 2006). This is because strong climate governance indicates heightened concern about climate change issues and can facilitate truthful disclosure of carbon performance so that shareholders and stakeholders are not misled.

Furthermore, boards with a motivation to monitor climate change issues may see through greenwashing attempts by management. This means that when climate governance mechanisms are strong, high polluters are unlikely to either pursue extensive disclosure intended to greenwash, or to reduce disclosure to avoid responsibility (Ntim & Soobaroyen, 2013). Hence, the potential gap between carbon disclosure and carbon performance is likely to be narrowed when firms have strong climate governance. We posit climate governance strengthens the link between carbon disclosure and carbon performance (i.e. enabling carbon disclosure to be more reflective of underlying carbon performance). Our third and fourth hypotheses are:

H3: There is a positive association between climate governance and carbon disclosure.

H4: The association between carbon disclosure and carbon performance is strengthened by climate governance.

3. Research Method

3.1 Sample selection

We focus on S&P 500 as these are the largest listed firms on the NYSE or NASDAQ. With substantial capitalisation, these firms are exposed to significant stakeholder and societal pressures to address their carbon emissions and to take leadership in climate change actions. We use the Carbon Disclosure Project (CDP) which provides the largest and most comprehensive database of voluntary reporting of carbon-related performance and activities (Luo and Tang, 2014; Matsumura, Prakash, & Vera-Muñoz, 2013).[6] We collect data from 2013 to 2015 as this is the period when the CDP questionnaires are consistent in format, thus

[6] Due to a highly structured questionnaire format, firms' responses to CDP are recognised to be faithful and reliable and reduce the risk of greenwashing (Depoers, Jeanjean, & Jérôme, 2016.

minimising the risk of missing variables, especially of carbon disclosure index. Data for carbon disclosure and performance are extracted from CDP databases while climate governance variables are coded based on CDP survey data. We obtained corporate governance data from BOARDEX and data for firm-level control variables from DataStream. After excluding missing variables, our final sample includes 361 firm-year observations that have carbon and financial information for two consecutive years, including 176 observations for 2014 and 185 observations for 2015 (Scalet & Kelly, 2010).[7] Table 1 reports the sample selection process. The sample distribution by industry is outlined in Panel A of Table 2.

[Insert Table 1 Panel A and B about here]

3.2 Regression models

We use equation 1, which measures carbon disclosure in year t, and equation 2, which measures the relative change in carbon disclosure in year t (compared to year t-1), to examine the impact of carbon performance, climate governance, and corporate governance on carbon disclosure. Further, using equation 1.1 we examine the impact of carbon performance, climate governance and components of corporate governance (as explained in section 3.3) on carbon disclosure. Similarly, using equation 2.1 we examine for the impacts of these components on the relative change in carbon disclosure. Equations 2 and 2.1 also control for the previous year disclosure, as it is likely that firms that already have extensive disclosure in the previous year might find it difficult to achieve a significant improvement in such disclosure in the following year, vis-à-vis firms with little disclosure and hence a significant scope to improve. Appendix 1 provides the list and definition of the variables.

[7] Our models include absolute disclosure index and change in disclosure index, carbon performance, and change in carbon performance. In order to compute changes in disclosure index and carbon performance for 2014, we collected carbon disclosure index and carbon performance data for the year 2013 for 176 firms and deducted them from the respective carbon disclosure index and carbon performance data for the year 2014 for the same firms.

$$DISC = a_0 + a_1CPER + a_2CLIG + a_3CPER*CLIG + a_4CORG + a_5SIZE + a_6ROA + a_7LEV + a_8TOBINSQ + a_9AGE + a_{10}CAPX + a_{11}ESI + a_{12}LITIGATION + a_{13}Industry\ dummy + a_{14}Year\ dummy + \omega \quad (1)$$

$$DISC = a_0 + a_1CPER + a_2B\_RESPONS + a_3EXEC\_INCENT + a_4FRE\_REPORT + a_5HORIZON + a_6B\_ENVI + a_7FEMALE + a_8B\_SIZE + a_9B\_IND + a_{10}DUALITY + a_{11}EXECOMP + a_{12}SIZE + a_{13}ROA + a_{14}LEV + a_{15}TOBINSQ + a_{16}AGE + a_{17}CAPX + a_{18}ESI + a_{19}LITIGATION + a_{20}Industry\ dummy + a_{21}Year\ dummy + \omega \quad (1.1)$$

$$\Delta DISC_{i,t} = a_0 + a_1\Delta CPER + a_2CLIG + a_3\Delta CPER*CLIG + a_4CORG + a_5DISC_{t-1} + a_6SIZE + a_7ROA + a_8LEV + a_9TOBINSQ + a_{10}AGE + a_{11}CAPX + a_{12}ESI + a_{13}LITIGATION + a_{14}Industry\ dummy + a_{15}Year\ dummy + \omega \quad (2)$$

$$\Delta DISC_{i,t} = a_0 + a_1\Delta CPER + a_2B\_RESPONS + a_3EXEC\_INCENT + a_4FRE\_REPORT + a_5HORIZON + a_6B\_ENVI + a_7FEMALE + a_8B\_SIZE + a_9B\_IND + a_{10}DUALITY + a_{11}EXECOMP + a_{12}DISC_{t-1} + a_{13}SIZE + a_{14}ROA + a_{15}LEV + a_{16}TOBINSQ + a_{17}AGE + a_{18}CAPX + a_{19}ESI + a_{20}LITIGATION + a_{21}Industry\ dummy + a_{22}Year\ dummy + \omega \quad (2.1)$$

Variables *CLIG*, *CPER* and *CORG* in the above equations are of main interest in our study and are expected to have a positive association with carbon disclosure.

3.3 Measurement of variables

Carbon disclosure (DISC)

We use the carbon disclosure index, *DISC* and *ΔDISC* measured by CDP, to reflect the extent and quality of carbon disclosure provided by firms. Carbon disclosure as measured and scored by CDP is considered as the most credible corporate environmental disclosure rating system in the world[8] (GlobeScan & SustainAbility, 2014). CDP disclosure index evaluates not only the completeness (quantity) but also the quality of a company's response (Tang & Luo, 2012). While some questions in the CDP questionnaire are binary (yes, 1 point awarded, or no, 0 point awarded), many require qualitative and narrative answers which are scored using content analysis following the standardised CDP Scoring Methodology. Scoring is based on a consideration of information quality including (a) the information details and

[8] This shows the credibility of CDP over ranking schemes with a longer history such as Dow Jones Sustainability Index or FTSE4Good Index Series.

relevance to the company, (b) examples or case studies provided, and (c) quantitative or financial information (Cotter & Najah, 2012).

Prior studies suggest CDP hard disclosure (quantitative information and indicators) is of higher quality and credibility than soft disclosure (descriptive or qualitative information) (Clarkson et al., 2008; Plumlee, Brown, Hayes, & Marshall, 2015). In a review of business reporting, Beattie, McInnes, and Fearnley (2004) suggest that the quality of disclosure can be discerned by different attributes of information, including historical/forward-looking, financial/non-financial, and quantitative/non-quantitative. Accordingly, CDP has specific questions that cover the future and strategic orientation of information; for example, C.C.2.1 is about the time horizon of risk information and risk strategy, and C.C.2.2 is about the integration of climate change into strategy. More points are given if firms disclose specific details of costs or investments in particular initiatives or state the financial implications of a certain risk or opportunity. The importance and materiality of specific information to certain users are also considered.[9]

Further, the CDP questionnaire covers many different aspects of climate change issues, including carbon control mechanisms, carbon strategies, carbon accounting and auditing, carbon initiatives, carbon risks and opportunities, and carbon communication and engagement. The final disclosure index is calculated using the total attained score divided by the total available score.[10] Hence the disclosure index reflects both the depth and breadth

[9] For example, the disclosure of gross direct carbon emissions data is given 6 points because this information is expected to be highly important and relevant to investors and regulators. CDP questionnaire and its scoring methods are very structured giving firms little discretion in omitting or providing misleading information (Luo et al., 2012). For example, a firm must answer all applicable questions, and answers left blank reduce the awarded score. If the firm states that it has an emissions reduction target, then it has to answer whether that target has been achieved, otherwise 1 point will be deducted. Hence, a higher point gained for each question indicates high quality information given for that item.

[10] As the score is scaled against the total available score, this becomes an index. Therefore, CDP disclosure index is also known as Carbon Disclosure Leadership Index (CDLI). However, the term "carbon disclosure score" is often used in prior research (Liao et al., 2015; Prado-Lorenzo & Garcia-Sanchez, 2010; Ben-Amar & McIlkenny, 2015) to refer to the same measure.

of corporate carbon information and a higher score denotes more comprehensive and higher quality disclosure.

In our models, firms participating in CDP receive a disclosure index from 0 to 100. A high disclosure index generally denotes not only more extensive disclosure, but also more quantitative focus in disclosure because quantitative information is given higher points than qualitative information.[11]

Carbon performance (CPER)

We develop three alternative measures of carbon performance. First, following prior studies (Chapple, Clarkson, & Gold, 2013; Luo & Tang, 2014), we measure emissions intensity (metric tons of carbon emissions per million dollars of revenue) as the total carbon emissions divided by the firm's sales revenue. Second, we use ΔCPER to measure the difference between current year and previous year emissions intensity. Third, we use a dummy variable ΔCPER_D to represent whether firms have reduced emissions intensity compared to the previous year (1 if it has reduced, or 0 otherwise).

Climate governance (CLIG)

Our composite measure of climate governance (CLIG) strength is based on the following components. First, we examine whether the board is responsible for climate change issues (*B_RESPONS*E), either via a separate board sub-committee or a board member. Further, we check whether there is some form of incentives related to climate change issues for executives (*EXEC_INCENT*). Prior literature suggests board oversight drives superior performance. Therefore, we examine whether the frequency of reporting to the board

[11] The final index for disclosure is determined based on firm's reporting on: governance, strategy, communications, and management sign-off (15%), energy and emissions performance and trading (12%), targets and initiatives (8%), Scope 1 & 2 verification (6%), Scope 3 (10%), risks and opportunities (29%), and emissions methodology and Scope 1/2 data (20%). CDP disclosure index is used in many prior studies on carbon disclosure (Matsumura et al., 2014; Ben-Amar & McIlkenny, 2015; Depoers et al., 2016; Ben-Amar, Chang, & McIlkenny, 2017).

(*FRE_REPORT*), time horizon of climate change risks considered (*HORIZON*), and board environmental committee (*B_ENVIR*) have an effect on disclosure. Following prior studies (Ben-Amar & McIlkenny, 2015; Zaman, Hudaib, & Haniffa, 2011), we add these components to obtain a composite score for climate governance *(CLIG)*.[12]

Corporate governance (CORG) and control variables

We include corporate governance components normally expected to be associated with sustainability disclosure and performance (Liao et al., 2015). To enable calculation of the composite score for corporate governance (CORG), we measure the components of corporate governance as dummy (1/0) industry-adjusted components. The variables are as defined in Appendix 1. Similar to Zaman et al. (2011), we combine the five components (*FEMALE, B_SIZE, B_IND, DUALITY* and *EXECOMP*) to obtain a composite score (*CORG*) for the strength of corporate governance. Consistent with prior disclosure studies, we include a number of control variables at the firm and industry levels. They include a firm's financial position (*SIZE*, *LEV*, *CAPX*), financial performance (*ROA*), innovation capability (*TOBINSQ*), and age of assets (*AGE*). For industry effects, we control whether the firm operates in an environmetnally sensitive industry (*ESI*) or a highly litigious industry (*LITIGATION*). Prior studies suggest that large, highly leveraged, environmentally sensitive or litigation-prone firms are subject to more intensive public and stakeholder pressures and, hence, are likely to adopt more extensive disclosure to manage reputation and legitimacy risk. Similarly, high capital-intensive firms or those with newer assets or with high innovation capability are likely to have more information asymmetry regarding their

[12] Most prior studies examine relationships between individual components of corporate governance and sustainability disclosure (Ntim & Soobaroyen, 2013; Michelon & Parbonetti, 2012), with only a few exceptions examine the impact of composite corporate governance scores on a sustainability disclosure index (e.g. Ben-Amar & McIlkenny, 2015) and audit fees (Zaman et al., 2011).

operations and activities and, thus, to use disclosure to inform shareholders about their underlying performance. Further description of the variables can be found in Appendix 1.

4. Findings

4.1 Descriptive statistics

Table 2 provides the descriptive statistics. *DISC* in 2015 has a mean (median) of 87.91 (93) and indicates firms have a high level of carbon disclosure. In 2014 the mean (median) is slightly lower, 83.02 (85), indicating that firms increase disclosure over time. The yearly change in disclosure index (*ΔDISC)* has a mean (median) of 4.89 (3). The mean emissions intensity (*CPER*) is 10.49 tonnes of CO2 per million-dollar revenue, with a yearly change of a decrease in mean of 0.11 tonnes in intensity. The mean for our composite *CLIG* score is 9.06. The mean for board responsibility (*B_RESPONS*) is 0.69, representing a high likelihood of the board being responsible for climate change issues. In contrast, executive incentives (*EXEC_INCENT*) is much lower (mean being 0.05), denoting that sample firms do not often incentivise the top executives[13] in relation to climate change issues. Reporting on climate issues (*FRE_REPORT*) has a mean of 3.41, indicating that climate change issues are reported to the board more often than just annually. Horizon of reporting (*HORIZON)* has a mean of 4.06, denoting a 3-6-year time frame of carbon information. Finally, *B_ENVIR* has a mean of 0.15 and indicates that a small portion of our sample firms have an environmental committee at the board level.

[Insert Table 2 about here]

4.2 Correlation analysis

[13] Firms do not incentivise their non-executive independent directors for climate change related issues. However, incentives are often used to motivate top executives, such as CEOs or CFOs.

Table 3 provides the Pearson correlations between the variables; the significance levels are reported as the two-tail *p* values. There is a negative and significant relationship between *CPER* and *DISC* (r=-0.15, p<0.01) and a significant positive association between Δ*CPER* and Δ*DISC* (r=0.16, p<0.01). This is consistent with hypothesis H1. In other words, high (low) emitters are less (more) likely to signal their carbon information. Having a larger reduction (increase) in emissions intensity induces firms to engage in stronger (weaker) voluntary disclosure. *DISC* and Δ*DISC* are not associated with the composite *CORG* or the individual corporate governance variables (except *FEMALE* and *B_SIZE*), hence providing initial evidence to reject H2.[14] In contrast, disclosure is positively associated with *CLIG* indicating that strong *CLIG* is associated with more extensive disclosure, supporting H3. Additionally, the interaction terms of *CPER*CLIG* and Δ*CPER*CLIG* are significant for both *DISC* and Δ*DISC* suggesting *CLIG* strengthens the relationship between carbon disclosure and carbon performance, consistent with H4. Overall, consistent with signalling theory and the monitoring effect of climate governance, the preliminary analysis provides support for H1, H3, and H4. Variance inflation factor tests indicate that multicollinearity is not an issue in the models.

[Insert Table 3 about here]

4.3 Multivariate analysis

In this section we report the results of multivariate OLS regression tests. Table 4 Panel A reports the influence of climate governance (*CLIG)* and corporate governance *(CORG)* on carbon disclosure. Model 4.1 focuses on the overall effects of *CLIG* and *CORG* (equation 1) whereas in Model 4.2 the focus is on the effects of the components of *CLIG* and *CORG* on carbon disclosure (equation 1.1). This helps to ascertain which components of *CLIG* and

[14] Note that to identify the overall as well as separate effect of the corporate governance and climate governance mechanisms, we test the effects of composite CORG and CLIG (equations 1 and 2) separately from the effects of the components of CORG and CLIG (equations 1.1 and 2.1).

CORG are the most significant in driving more extensive carbon disclosure. All regression equations have adjusted *R*-square above 0.24. The reported significance levels are two-tail *p* values.

The results in Table 4 Panel A show that the coefficients of *CPER* are negative and significant in all models (*Coff* =-0.39, p<0.01 in Model 4.1 and *Coff*=-0.08, p<0.01 in Model 4.2). Hence, H1 predicting a positive association between carbon performance and disclosure is supported. Our findings are consistent with Al-Tuwaijri et al. (2004), Clarkson et al. (2008), Luo and Tang (2014), and Qian and Schaltegger (2017) which suggest carbon-intensive firms are likely to be sensitive to their environmental responsibility image, hence reducing the extent of their carbon disclosure to hide poor performance. In contrast, to distinguish themselves from industry peers, high-performing firms leverage their carbon performance by actively communicating to stakeholders.

Further, traditional corporate governance strength (*CORG*) is not associated with higher carbon disclosure (*Coff*=1.03, p>0.10, Model 4.1).[15] This result is not consistent with H2. In contrast to Garcia-Meca and Sánchez-Ballesta (2010) and Liao et al. (2015) but is in line with Michelon and Parbonetti (2012), our findings suggest stronger corporate governance does not equate to the interests of relevant stakeholders being better represented and catered for. We find some support for Prado-Lorenzo and Garcia-Sanchez's (2010) argument that boards may be focused on creating economic value instead of pursuing sustainability.[16]

In contrast to traditional corporate governance, climate governance *(CLIG)* seems to drive higher carbon disclosure index (*Coff*=1.91, p<0.01, Model 4.1), hence supporting H3.

[15] Our findings also show that corporate governance components (namely, *FEMALE*, *B_SIZE*, *B_IND*, *DUALITY,* and *EXECOMP*) do not appear to influence disclosure (see Table 4 Panel A, Model 4.2).

[16] Traditional corporate governance does not focus on expertise in climate change issues or create a strong interest in addressing them. For example, board independence or board diversity does not mean that directors have expertise in climate change issues. Further, executives are mainly held accountable and rewarded for financial performance. This potentially may explain the weak linkage between corporate governance and carbon disclosure.

Firms with stronger climate governance pursue more extensive carbon disclosure. Furthermore, we find support for H4 relating to climate governance strengthening the relationship between carbon disclosure and carbon performance (*CPER*CLIG, Coff*=0.04, p<0.05, Model 4.1). While carbon disclosure is reflective of the underlying carbon performance, good carbon performers may oversell their performance through extensive disclosure, while poor performers may use minimal disclosure to hide the underlying performance from external scrutiny. This may distort shareholder and stakeholder perceptions of underlying carbon performance. Indeed, our findings suggest that strong *CLIG* reduces this managerial discretion over disclosure by reducing the disclosure gap between poor and strong carbon performers. These insights are new to the literature, suggesting a crucial role played by climate governance in reducing the propensity of firms using disclosure to greenwash, hide, or justify poor carbon performance (Ntim & Soobaroyen, 2013; Alrazi et al., 2016).

A closer investigation into the constituents of climate governance, *CLIG*, reveals that only the risk horizon (*HORIZON, Coff*=2.68, p<0.01, Model 4.2) plays a vital role in influencing carbon disclosure. We find *B_RESPONS*, *EXEC_INCENT*, *FRE_REPORT* and *B_ENVIR* are not statistically significant (see Model 4.2). These results suggest boards' accountability and executive incentives for climate change issues do not guarantee more carbon disclosure, possibly due to carbon being a multi-dimensional issue, and it is not sufficient to confine responsibility for climate change issues solely to the board or top management. Additionally, it is possible that when the objectives of profit maximisation and carbon efficiency conflict, boards favour the former in the interest of shareholders. Additionally, similar to Michelon and Parbonetti (2012), we do not find that presence of an environmental committee affects carbon disclosure. An environmental committee, often also known as a corporate social responsibility (CSR) committee, may oversee many social and environmental issues and carbon might not be its top priority. Further, the small

number of firms with an environmental committee (15% in our sample) indicates that an environmental committee may not be a strong driver of whether and to what extent a firm decides to disclose its carbon information.

In contrast to prior studies, we find the coefficients of *SIZE*, *ROA*, *LEV*, and *AGE* are not statistically significant (p>0.10) whereas *TOBINSQ* is significant (*Coff*=2.12, p<0.05, Model 4.2).[17]

[Insert Table 4 Panel A about here]

Table 4 Panel B reports the findings based on equations 2 and 2.1 for year-on-year change in disclosure level *(ΔDISC)*. The adjusted *R*-squares of all regressions are over 0.28. After controlling for previous year disclosure index, we find the link between carbon disclosure and carbon performance weakens. Change in carbon disclosure index is not significantly associated with the (absolute) change in carbon emissions intensity *(ΔCPER, Coff*=0.04, p>0.10, Model 4.3) but it is significantly associated with whether intensity reduces compared to the previous year *(ΔCPER_D, Coff*=8.21, p<0.05, see Model 4.4). This is consistent with signalling theory whereby firms that improve their carbon performance have incentives to disclose more to highlight their efforts. Furthermore, change in disclosure is also negatively associated with the previous year's disclosure index, suggesting that carbon disclosure can have a disciplinary effect on firms participating in the CDP. Hence, firms with a poor disclosure index are likely to be obliged to improve their disclosure to improve their reputation.

The results based on equations 2 and 2.1 reported in Panel B of Table 4 are generally consistent with the findings based on equations 1 and 1.1 reported earlier in Panel A of

[17] It is worth noting that our sample includes only S&P 500 firms that CDP disclosure index is available publicly. Given the superior financial position of these firms, they are subject to intense scrutiny from investors, so making carbon disclosure an expected practice by these companies to adequately inform investors. Hence, the financial performance and carbon disclosure linkage weakens.

Table 4. We find *CORG* as well as its individual components are not significantly associated with change in disclosure (p>0.10). In contrast, we find climate governance (*CLIG, Coff*=0.93, p<0.01, Model 4.3) is positively associated with change in disclosure index. The negative and significant association between the interaction term *ΔCPER_D*CLIG* (*Coff*=-0.76, p<0.1, Model 4.4) and *ΔDISC* confirms our expectation that *CLIG* constrains the ability to over-acclaim good performance via extensive increases in disclosure, hence narrowing the disclosure gap between improving and worsening carbon performers.

Furthermore, the results in Panel B of Table 4 confirm that more frequent internal reporting on carbon to the board *(FRE_REPORT, Coff* =1.58, p<0.01 in Model 4.5) is associated with an increase in the external disclosure level in the following year. This indicates that boards become more aware and take a more active interest in climate change issues, hence carbon information is reported to them more frequently, leading to more comprehensive explanation of carbon performance in external disclosure. This insight extends Luo and Tang's (2014) study which does not identify which risk reporting characteristics affect carbon disclosure.

[Insert Table 4 Panel B about here]

Overall, our findings differ from earlier studies (e.g. Ntim & Soobaroyen, 2013; Liao et al., 2015) which suggest strong corporate governance leads to more extensive carbon disclosure. In contrast our results suggest the integration of climate change issues into governance through climate-embedded governance mechanisms facilitates communication and engagement with stakeholders on climate change issues. We find the frequency of carbon reporting and time horizon of carbon information considered by boards are important contributors to improving carbon disclosure.

4.4 Additional analysis

Table 5 Panels A and B report the findings for the sub-samples divided based on strength of climate governance, emissions intensity, and year. Firms with varying degrees of climate governance and/or emissions intensity may behave differently; therefore, dividing the sample along these criteria can help better understand the impact of our main variables of interests on carbon disclosure. Hence, firms with a composite score of *CLIG* higher (lower) than the industry median are classified as strong (weak) *CLIG*. We apply the same basis of categorisation for emissions intensity.

The impact of *CLIG* on disclosure holds across all types of firms (Table 5 Panel A), indicating that strong *CLIG* motivates management to communicate carbon information more extensively. The impact of carbon performance on disclosure remains for weak governance (*Coff*=-0.54, p<10%, Model 5.2) and low-intensity firms (*Coff*=-0.30, p<10%, Model 5.4). Further, the coefficients of the interaction between climate governance and carbon performance (*CPER*CLIG*) is only statistically significant for weak governance firms (*Coff*=0.05, p<0.10 in Model 5.2). This could be because management in firms with weak governance enjoy significant discretion, and hence a point increase in *CLIG* has the potential to reduce such discretion more.

We also find that emissions intensity is not associated with the extent of disclosure among strong governance and high-intensity firms (Models 5.1. and 5.3). Managers in firms with strong climate governance may have reduced managerial discretion, hence producing less variation in carbon disclosure. Further, consistent with prior research (Matsumura et al., 2014), we contend that high-intensity firms need to balance legitimacy threats associated with the disclosure of high emissions levels and the premium on cost of capital for failure to disclose. With carbon performance being worse than the industry median, these costs may essentially be equivalent, thus making these firms indifferent to more or less disclosure. The results of Table 5 Panel B regarding the drivers of the change in disclosure are essentially the

same as the main regression results reported in Table 4 Panel B. Splitting the sample based on climate governance strength, emissions intensity, and year does not affect our findings.

[Insert Table 5 and B about here]

To assure the validity of our findings, we perform several robustness tests. First, we undertake further analysis based on hard and soft disclosure following Hollindale et al. (2019), whereby soft disclosure includes information on vision and strategy, environmental profile, and environmental initiatives. Second, we exclude the telecommunication services industry which has the lowest number of observations. Third, the disclosure index, absolute emissions intensity, and financial variables are adjusted by industry median (by taking the deviation of firm value from industry median). Fourth, we compute alternative measures of *CLIG* and *CORG* by extracting the principle component analysis (PCA) of their respective components. The untabulated results support our previous findings regarding the influence of carbon performance, climate governance, and corporate governance on carbon disclosure.

5. Summary and Conclusion

This paper examines the impact of the integration of climate change issues into governance mechanisms on the relation between carbon disclosure and carbon performance. The results confirm our hypotheses about the impact of climate governance, with stronger climate governance mechanisms strengthening the link between carbon disclosure and carbon performance and reducing managerial discretion over carbon disclosure.

Our study makes three key contributions to the literature. First, it contributes to the emerging literature on carbon disclosure-performance relationship (Luo & Tang, 2014; Qian & Schaltegger, 2017). While prior studies have focused on environmental disclosure and environmental performance, our analysis is focused on climate change issues. This enables us to capture one defined aspect as opposed to the multi-faceted, broad measures of

environmental performance/disclosure often used in prior research. Our findings support a signalling effect of carbon disclosure and suggest that low polluters disclose more to differentiate themselves and to achieve a competitive advantage, while high polluters disclose less to conceal poor performance and/or avoid managerial responsibility associated with such performance. A potential explanation for the signalling effect, rather than a legitimacy effect, may be due to our sampling choice of S&P 500 firms. These firms generally have strong financial performance and receive significant scrutiny from the market, rendering greenwashing efforts (i.e. extensive disclosure to mask poor performance) potentially counterproductive.

Second, our study is the first to document the impact of a distinct aspect of governance, i.e. climate governance mechanisms, on carbon disclosure. Our results reveal a strong, positive, and significant impact of climate governance, suggesting that firms that integrate climate change issues into their governance mechanisms disclose more to reduce information asymmetry. In particular, the frequency of reporting to the board and time horizon of carbon information seem to play a vital role in affecting carbon disclosure. Interestingly, we find that stronger climate governance narrows the gap in disclosure between high polluters and low polluters, and between firms that improve carbon performance and those that do not. Our results suggest that climate governance reduces managerial discretion on carbon disclosure; specifically, in over-acclaiming of high performance via extensive disclosure, and hiding or avoiding responsibility for poor performance via minimal disclosure. Hence, climate governance can enable carbon disclosure to represent carbon performance more truthfully.

Third, we do not find a significant association between commonly used measures of corporate governance (including board diversity, size, independence, duality, and executive compensation) and carbon disclosure. This contrasts with many prior studies that find some aspects of corporate governance impact on sustainability disclosure. By capturing a narrow

and focused aspect of sustainability disclosure (i.e. carbon), we provide more nuanced evidence on the impact of corporate governance. For example, previous sustainability disclosure measures may capture both performance and governance aspects, rather than environmental or social aspects alone. Our findings suggest that as far as climate change issues are concerned, traditional governance mechanisms (such as board diversity, independence, and size) do not translate into commitment to addressing sustainability issues or providing more transparent reporting on carbon.

Our study is subject to several limitations. Due to examining S&P 500 firms our findings are not necessarily generalisable to other U.S. firms or those operating in other jurisdictions. Further, our sample firms operate in a voluntary context and hence the discrepancy (and managerial discretion) between disclosure and performance might be much less under a regulatory context such as the European Union Emissions Trading Scheme (EU ETS). Also, our study is based on the CDP measure of carbon disclosure index and hence does not examine the effect of climate governance on a firm's wider climate-related actions. Finally, our paper provides evidence of association only. Further research into causal relationship, endogenous issues, as well as exploration of different logics that may affect the relationship between climate governance and carbon disclosure-performance is needed. These limitations may be addressed in future research investigating the effect of climate governance on the internal management of climate change issues (see Subramaniam, Wahyuni, Cooper, Leung, & Wines, 2015; Bui & de Villiers, 2017b; Arena et al., 2018), and the wider accountability of firms to stakeholders. In particular, future research on climate governance can add further insights using longitudinal data and focus on differences in institutional settings internationally. Future research can also help evaluate the influence of climate governance on other forms of voluntary non-financial reporting such as sustainability and integrated reporting. Overall, however, our results suggest the integration of climate change issues into governance through climate-embedded governance

mechanisms facilitates communication and engagement with stakeholders on climate change issues.

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Table 1 Panel A: Sample selection process

S&P 500 firm-year observations for two years 2014 and 2015	**1000**
Less:	
Firm-year observations whereby firms do not respond to CDP, or emissions intensity, carbon disclosure index and climate governance components are missing for two years 2014 and 2015	**(628)**
Firm-year observations whereby the control variables are missing	**(11)**
Usable observations	**361**

Table 1 Panel B: Sample distribution by industry

Industry	Observations	Frequency
Consumer Discretionary	51	14.1
Consumer Staples	55	15.2
Energy	22	6.1
Financials	23	6.4
Health Care	39	10.8
Industrials	59	16.3
Information	51	14.1
Materials	27	7.5
Telecommunication Services	06	1.7
Utilities	28	7.8
Total	361	100.0

Table 2: Descriptive statistics

Variable	Mean	Median	Std. Dev	Min	Max.	Percentile (25)	Percentile (75)
DISC(1)	87.91	93.00	13.02	34.00	100.00	81.00	98.00
$DISC_{t-1}$(2)	83.02	85.00	13.93	34.00	100.00	74.50	95.00
ΔDISC(3)	4.89	3.00	8.43	-21.00	38.00	0.00	9.00
CPER(4)	10.49	0.00	25.13	0.00	95.60	0.00	0.03
ΔCPER(5)	-0.11	0.00	23.80	-95.60	76.50	0.00	6.07
ΔCPER_D(6)	0.66	1.00	0.48	0.00	1.00	0.00	1.00
CORG(7)	2.13	2.00	1.12	0.00	5.00	1.00	3.00
CLIG(8)	9.06	9.00	2.05	0.00	12.00	8.00	10.00
CPER*CLIG(9)	98.31	0.01	245.68	0.00	10.51.60	0.00	0.21
ΔCPER* CLIG(10)	-4.38	0.00	226.91	-1023.00	841.50	0.00	46.22
ΔCPER_D* CLIG(11)	5.97	8.00	4.61	0	12	0.00	10.00
B_RESPONSE(12)	0.69	1.00	0.46	0.00	1.00	0.00	1.00
EXEC_INCENT(13)	0.05	0.00	0.21	0.00	1.00	0.00	0.00
FRE_REPORT(14)	3.41	4.00	0.79	0.00	4.00	3.00	4.00
HORIZON(15)	4.06	4.00	1.20	0.00	5.00	4.00	5.00
B_ENVIR(16)	0.15	0.00	0.36	0.00	1.00	0.00	0.00
FEMALE(17)	0.43	0.00	0.50	0.00	1.00	0.00	1.00
B_SIZE(18)	0.35	0.00	0.48	0.00	1.00	0.00	1.00
B_IND(19)	0.45	0.00	0.50	0.00	1.00	0.00	1.00
DUALITY(20)	0.02	0.00	0.14	0.00	1.00	0.00	0.00
EXECOM(21)	0.73	1.00	0.45	0.00	1.00	0.00	1.00
SIZE(22)	23.81	23.78	1.01	21.81	25.57	23.00	24.52
ROA(23)	0.07	0.07	0.05	-0.06	0.16	0.04	0.10
LEV(24)	0.30	0.29	0.14	0.05	0.58	0.20	0.40
TOBINSQ(25)	1.57	1.35	0.96	0.29	3.58	0.85	2.05
AGE(26)	0.49	0.47	0.13	0.30	0.79	0.40	0.58
CAPX(27)	0.10	0.05	0.12	0.01	0.49	0.03	0.10
ESI(28)	0.19	0.00	0.39	0.00	1.00	0.00	0.00
LITIGATION(29)	0.12	0.00	0.32	0.00	1.00	0.00	0.00

Variable definitions: See Appendix 1.

Table 3: Pearson correlation matrix

Variable(s)	1	2	3	4	5	6	7	8	9	10	11	12	13
1	1												
2	.81***	1											
3	.21***	-.41***	1										
4	-.15***	-.13**	.03	1									
5	.15***	.04	.16***	.71***	1								
6	.10**	.09*	.01	-.49***	.49***	1							
7	.08	.04	.06	.09*	-.05	-.05	1						
8	.41***	.32***	.09*	.07	-.07	.01	.20***	1					
9	-.11**	-.09*	-.03	.78***	-.49***	-.47***	.10*	.13**	1				
10	.15***	.04	.17***	-.50***	.48***	.47***	-.04	-.03	-.51***	1			
11	.18***	.16***	.03	-.46***	.45***	.53***	.01	.29***	-.44***	.46***	1		
12	.13**	.12**	.01	.04	-.06	.03	.17***	.38***	.07	-.06	.14***	1	
13	.09	.12**	-.06	-.02	.01	.08	.13**	.25***	-.02	.02	.17***	.15***	1
14	.29***	.18***	.14***	.03	-.05	-.01	.17***	.57***	.08	-.02	.22***	.14***	.12**
15	.36***	.31***	.05	.06	-.05	-.01	.09*	.55***	.11**	-.02	.24***	.11**	.09*
16	-.03	-.07	.07	.01	.02	.01	.31***	.06	.01	.03	.04	.12**	-.02
17	.09*	.09*	-.01	.06	-.05	-.03	.40***	.12**	.07	-.04	.01	.04	-.01
18	.12**	.11**	.01	.07	-.06	-.02	.36***	.14***	.07	-.05	.03	.19***	.07
19	-.02	-.04	.05	.15***	-.14***	-.15***	.46***	.09*	.15***	.13**	-.10*	.09*	.05
20	.02	.01	.01	-.06	.11**	.02	.15***	-.02	-.06	.10**	.01	.01	-.03
21	-.01	-.05	.07	-.06	.03	.01	.36***	.05	-.08	-.04	.05	.09*	.14***
22	.09*	.13**	-.06	-.06	.04	.01	.24***	.11***	-.04	.03	.04	.09	.04
23	-.02	.02	-.05	.09*	-.09*	.01	-.09	-.11**	.08	-.11**	-.04	-.15***	.01
24	.10*	.03	.10*	.10*	-.06	-.07	.01	.16***	.11**	-.05	-.02	.03	-.02
25	.04	.05	-.02	.06	-.03	.04	-.08	-.05	.05	-.03	.01	-.22***	.06
26	.14***	.16***	-.05	-.11**	.04	.15***	.02	.23***	-.08	.05	.20***	.09*	.11**
27	-.01	-.01	.01	-.10*	.07	-.01	.13**	.08	-.08	.07	.02	.05	.02
28	-.03	-.03	-.00	.08	-.04	-.07	.26***	.05	.08	-.03	-.06	.01	-.04
29	-.08	-.04	-.05	.07	-.01	-.06	.09*	-.12**	.07	-.04	-.10*	-.16***	-.04

Table 3: continued

Variable(s)	14	15	16	17	18	19	20	21	22	23	24	25	26	27	28	29
14	1															
15	.50***	1														
16	.06	.02	1													
17	.07	.09*	.02	1												
18	.06	.07	-.03	.05	1											
19	.06	.06	.10*	.07	.15***	1										
20	-.05	-.01	.22***	-.05	-.02	-.06	1									
21	.08	-.05	-.07	-.02	-.04	.09*	.04	1								
22	.02	.10*	-.01	.08	.32***	.21***	.01	.05	1							
23	-.09	-.05	-.16***	.13**	-.05	-.09	-.17***	-.01	-.27***	1						
24	.13**	.15***	.02	.01	.04	.07	-.01	.04	.03	-.12**	1					
25	.01	-.01	-.13**	.15***	-.08*	-.17***	-.05	-.03	-.41***	.57***	-.09*	1				
26	.19***	.17***	.15***	-.06	.09*	-.08	.02	.04	.28	-.27***	.18***	-.27***	1			
27	.10*	.06	.29***	-.12**	-.09*	.08	.25***	.03	.20***	-.49***	.12**	-.41***	.46***	1		
28	-.01	.05	.21***	.07	.04	.18***	.29***	.04	.12**	-.08	-.02	.08	-.08	.22***	1	
29	-.13**	-.03	-.08	.00	-.12**	.05	.01	.07	.08	.16***	-.10**	.13**	-.16***	-.15***	.21***	1

Note: Coefficient p-values are two-tailed. *** p<0.01, ** p<0.05, * p<0.1,

In the correlation the variable numbers refer to: 1= DISC, 2= $DISC_{t-1}$, 3=ΔDISC,4= CPER, 5=ΔCPER, 6=ΔCPER_D, 7= CORG, 8= CLIG, 9= CPER*CLIG, 10=ΔCPER* CLIG, 11=ΔCPER_D* CLIG, 12= B_RESPONSE, 13= EXEC_INCENT, 14= FRE_REPORT, 15= HORIZON, 16= B_ENVIR, 17= FEMALE, 18= B_SIZE, 19= B_IND, 20= DUALITY, 21= EXECOM, 22= SIZE, 23= ROA, 24= LEV, 25= TOBINSQ, 26= AGE, 27= CAPX, 28= ESI, and 29= LITIGATION. The variables are defined in Appendix 1.

Table 4 Panel A: Drivers of carbon disclosure (DISC)

Variable(s)	4.1 DISC		4.2 DISC	
	Coefficient	t-stat	Coefficient	t-stat
(Constant)	45.63***	2.64	42.06**	2.36
CPER	-0.39***	-2.61	-0.-08***	-3.06
CLIG	1.91***	5.29		
CPER*CLIG	0.04**	2.12		
CORG	1.03	1.40		
B_RESPONSE			1.81	1.25
EXEC_INCENT			3.34	1.10
FRE_REPORT			1.41	1.51
HORIZON			2.68***	4.24
B_ENVIR			-1.60	-0.83
FEMALE			14.24	1.63
B_SIZE			0.64*	1.68
B_IND			-3.70	-0.45
DUALITY			3.58	0.74
EXECOMP			0.17	0.12
SIZE	0.96	1.32	0.60	0.76
ROA	-9.13	-0.50	-9.80	-0.53
LEV	2.31	0.46	2.99	0.58
TOBINSQ	2.26**	2.26	2.12**	2.06
AGE	11.04*	1.73	11.40	1.72
CAPX	-16.33*	-1.85	-13.08	-1.44
ESI	0.06	0.26	-0.21	-0.08
LITIGATION	-0.071	-0.29	0.86	0.34
Industry dummy	Yes		Yes	
Year dummy	Yes		Yes	
N	361		361	
Adjusted R^2	0.29		0.24	

Variable definitions: See Appendix 1. Standard errors are clustered by firm. Robust t-statistics in column 3 and 5. *** p<0.01, ** p<0.05, * p<0.1, based on two-tailed tests.

Table 4 Panel B: Drivers of change in carbon disclosure (ΔDISC)

Variable(s)	4.3 ΔDISC		4.4 ΔDISC		4.5 ΔDISC	
	Coefficient	t-stat	Coefficient	t-stat	Coefficient	t-stat
(Constant)	29.54***	2.76	25.40**	2.33	22.28**	2.00
ΔCPER	0.04	0.48			0.06***	3.85
ΔCPER_D			8.21**	2.28		
CLIG	0.93***	4.16	1.42***	3.85		
ΔCPER*CLIG	0.00	0.34				
ΔCPER_D*CLIG			-0.76*	1.81		
CORG	0.71	1.54	0.70	1.52		
B_RESPONSE					0.58	0.63
EXEC_INCENT					-1.17	-0.61
FRE_REPORT					1.58***	2.69
HORIZON					0.74*	1.82
B_ENVIR					0.46	0.38
FEMALE					3.16	0.57
B_SIZE					0.28	1.18
B_IND					3.46	0.68
DUALITY					0.30	0.10
EXECOMP					0.83	0.92
$DISC_{t-1}$	-0.31***	-10.57	-0.32***	-10.68	-0.31***	-10.14
SIZE	-0.31	-0.66	-0.29	-0.63	-0.40	-0.81
ROA	-1.22	-0.11	-2.75	-0.24	-0.39	-0.03
LEV	4.77	1.52	4.32	1.36	4.57	1.43
TOBINSQ	0.41	0.65	0.39	0.61	0.32	0.49
AGE	2.89	0.73	2.02	0.50	2.85	0.68
CAPX	-8.46	5.51	-7.19	-1.29	-7.62	-1.34
ESI	-0.26	-0.17	-0.21	-0.13	-0.35	-0.22
LITIGATION	-1.08	-0.69	-1.37	-0.88	-1.07	-0.68
Industry dummy	Yes		Yes		Yes	
Year dummy	Yes		Yes		Yes	
N	361		361		361	
Adjusted R^2	0.30		0.28		0.29	

Variable definitions: See Appendix 1. Standard errors are clustered by firm. Robust t-statistics in columns 3, 5 and 7. *** p<0.01, ** p<0.05, * p<0.1, based on two-tailed tests.

Table 5 Panel A: Drivers of carbon disclosure (DISC) - Additional analysis

Variable(s)	5.1 DISC	5.2 DISC	5.3 DI8C	5.4 DISC	5.5 DISC	5.6 DISC
	Strong governance	Weak governance	High Intensity	Low Intensity	2014	2015
	Coefficient (t-stat)	Coefficient (t-stat)	Coefficient (t-stat)	Coefficient (t-stat)	Coefficient (t-stat)	Coefficient (t-stat)
(Constant)	110.18***	19.98	68.89***	31.90	42.22	43.85*
	(5.27)	(0.52)	(3.23)	(1.12)	(1.46)	(1.68)
CPER	-0.18	-0.54*	-11853.87	-0.30*	-0.61***	0.05
	(-0.87)	(-1.71)	(-0.00)	(-1.76)	(-2.98)	(1.24)
CLIG	1.86***	1.84**	1.82***	1.79***	1.89***	2.29
	(3.78)	(2.56)	(3.08)	(3.56)	(3.56)	(1.42)
CPER*CLIG	-0.01	0.05*	865.38	0.03	0.05**	-0.01
	(-1.15)	(1.65)	(0.09)	(0.56)	(2.12)	(-1.06)
CORG	1.02	-0.58	0.58	-0.09	0.69	0.69
	(0.56)	(-0.82)	(1.26)	(-1.08)	(1.04)	(0.89)
SIZE	-1.68	1.96***	-0.02	1.41	0.87	0.37
	(-1.28)	(2.98)	(-0.54)	(0.86)	(0.68)	(0.64)
ROA	6.73	-24.83	12.75	2.73	-28.95	18.92
	(1.04)	(-0.86)	(1.24)	(0.95)	(-0.56)	(1.42)
LEV	9.53	1.56	10.03	0.19	0.33	6.58
	(0.87)	(0.45)	(1.02)	(0.88)	(0.69)	(0.69)
TOBINQ	-1.01	3.95***	0.68	2.59	2.65	1.43
	(-1.01)	(3.46)	(0.52)	(0.68)	(0.64)	(1.68)
AGE	8.50	4.34	7.17	12.67	2.29	20.98***
	(1.13)	(0.83)	(1.03)	(1.42)	(0.46)	(3.24)
CAPEX	-29.58*	-1.00	-11.50	-7.64	-5.73	-22.29**
	(-1.72)	(-0.04)	(-0.89)	(-0.86)	(-0.63)	(-2.46)
ESI	17.02***	-4.70*	0.10	1.56	3.25	-1.89
	(4.26)	(-1.65)	(0.62)	(0.86)	(1.26)	(-0.75)
LITIGATION	-9.97*	4.17	8.04**	-7.77**	-0.27	0.09
	(1.69)	(0.68)	(2.39)	(-2.56)	(-0.45)	(0.36)
Industry dummy	Yes	Yes	Yes	Yes	N.A.	N.A.
Year dummy	Yes	Yes	Yes	Yes	Yes	Yes
N	131	230	176	185	176	185
Adjusted R^2	0.29	0.19	0.20	0.33	0.31	0.19

This table reports the results of additional analysis of disclosure based on sub-groups. Variable definitions: See Appendix 1. Standard errors are clustered by firms. Robust t-statistics in parentheses. *** p<0.01, ** p<0.05, * p<0.1, based on two-tailed tests.

Table 5 Panel B: Drivers of change in carbon disclosure (ΔDISC) - Additional analysis

Variable(s)	5.7 ΔDISC	5.8 ΔDISC	5.9 ΔDISC	5.10 ΔDISC	5.11 ΔDISC	5.12 ΔDISC
	Strong Governance	Weak governance	High Intensity	Low Intensity	2014	2015
	Coefficient (t-stat)	Coefficient (t-stat)	Coefficient (t-stat)	Coefficient (t-stat)	Coefficient (t-stat)	Coefficient (t-stat)
(Constant)	51.04**	20.76	30.04**	18.27	42.47***	24.50*
	(2.42)	(1.04)	(2.38)	(0.98)	(3.27)	(1.68)
ΔCPER	-0.01	0.06	0.10	0.05	0.11	-0.07
	(-0.64)	(0.56)	(1.06)	(0.67)	(0.76)	(-0.86)
CLIG	1.18***	0.79	0.83**	0.88***	0.94***	0.82***
	(3.04)	(0.48)	(2.54)	(2.84)	(3.04)	(2.52)
ΔCPER*CLIG	0.01	0.00	0.00	9.73E-5	-0.00	0.01
	(1.34)	(1.28)	(1.14)	(0.00)	(-0.46)	(0.98)
CORG	0.88	0.30	0.12	0.62	0.44	0.81*
	(1.02)	(0.98)	(0.42)	(1.42)	(1.28)	(1.71)
$DISC_{t-1}$	-0.24***	-0.39***	-0.35***	-0.30***	-0.24***	-0.38***
	(-3.56)	(-3.85)	(-3.68)	(-3.58)	(-3.54)	(-3.72)
SIZE	-1.54*	0.30	-0.21	0.02	-1.16*	-0.18
	(1.78)	(0.58)	(-0.58)	(0.68)	(-1.68)	(-0.98)
ROA	-15.26	-5.44	2.36	4.24	-16.31	19.36
	(-0.96)	(-0.46)	(0.25)	(0.36)	(-0.23)	(0.12)
LEV	1.22	6.20	7.81	3.35	7.55	4.86
	(0.88)	(0.68)	(0.52)	(0.82)	(0.54)	(0.62)
TOBINSQ	0.66	0.93	-0.01	0.94	-0.27	0.55
	(1.03)	(1.25)	(-0.76)	(1.23)	(-0.42)	(0.76)
AGE	0.03	1.43	0.88	2.69	-7.98	13.10**
	(0.78)	(1.26)	(1.14)	(1.34)	(-0.64)	(2.06)
CAPX	-4.68	-6.08	-0.25	-9.33	4.43	-19.08***
	(-0.64)	(-0.78)	(-0.34)	(-0.92)	(0.94)	(-4.68)
ESI	1.21	-2.10	-3.01	0.74	2.64	-2.42
	(0.76)	(-0.54)	(-0.42)	(0.68)	(1.12)	(-0.46)
LITIGATION	-0.13	-0.18	2.64	-3.28	-0.92	-1.37
	(-0.56)	(-0.48)	(1.12)	(-0.34)	(-0.78)	(-0.64)
Industry dummy	Yes	Yes	Yes	Yes	Yes	Yes
Year dummy	Yes	Yes	Yes	Yes	Yes	Yes
N	131	230	176	185	176	185
Adjusted R^2	0.22	0.35	0.30	0.28	0.17	0.38

This table reports the results of additional analysis of change in disclosure based on sub-groups Variable definitions: See Appendix 1. Standard errors are clustered by firms. Robust t-statistics in parentheses. *** p<0.01, ** p<0.05, * p<0.1, based on two-tailed tests.

Appendix 1: Variable Descriptions

Variable	Label	Definition
Dependent variables		
DISC(1)	Carbon disclosure	Carbon disclosure index of firm *i* in year *t*. The index ranges from 0 to 100.
$DISC_{t-1}$(2)	Previous year carbon disclosure	One-year lag disclosure index of firm *i* in year *t*.
ΔDISC(3)	Change in carbon disclosure	Difference between current and previous year disclosure index of firm *i* in year *t*.
Independent variables		
CPER(4)	Carbon performance	Emissions intensity, calculated by Scope 1 plus scope 2 carbon emissions (metric tonnes of carbon emissions per million dollar of revenue) scaled by sales revenue of firm *i* in year *t*.
ΔCPER(5)	Change in carbon performance	Difference between previous and current year emissions intensity of firm *i* in year *t*.
ΔCPER_D(6)	Dummy variable for change in carbon performance	Dummy variable: If emissions intensity reduces compared to previous year = 1, otherwise 0, of firm *i* in year.
CORG(7)	Corporate governance	Strength of corporate governance of firm *i* in year *t*, computed as a composite score by totalling the six corporate governance components [i.e. FEMALE (0-1), B_SIZE (0-1), B_IND (0-1), B_ENVIR (0-1), DUALITY (0-1), and EXECOMP (0-1)] as explained below. Hence, the composite score ranges from 0 to 6.
CLIG(8)	Climate governance	Strength of climate governance of firm *i* in year *t*, computed as a composite score by totalling the five climate governance components [i.e., B_RESPONS (0-1), EXEC_INCENT (0-1), FRE_REPORT (0-4), HORIZON (0-5) and B_ENVIR (0-1)]. Hence, the composite score ranges from 0 to 12.
CPER*CLIG(9)		The interaction terms of CPER*CLIG, of firm i in year t.
ΔCPER*CLIG(10)		The interaction terms of ΔCPER*CLIG, of firm i in year t.
ΔCPER_D*CLIG(11)		The interaction terms of CPER_D*CLIG, of firm i in year t.
B_RESPONSE(12)	Board responsibility	Dummy variable: If the board or a sub-committee of the board is responsible for climate change = 1, otherwise 0, of firm *i* in year *t*.
EXEC_INCENT(13)	Executive incentives	Dummy variable: If the company provides climate change incentives for executives =1, otherwise 0, in year *t*.
FRE_REPORT(14)	Frequency of carbon reporting	If climate change is reported: semi-annually =4 points; annually = 3 points; every 2 years =2 points; sporadically or not defined =1 point; none =0 point, of firm *i* in year *t*.
HORIZON(15)	Horizon of carbon information	If the carbon risk horizon is considered as far as: more than 6 years =5 points; 3-6 years =4 points; 1-3 years =3 points; up to 1 year =2 points; unknown =1 point; none =0, of firm *i* in year *t*.
B_ENVIR(16)	Board environmental committee	Dummy variable: If the company has a board-level environmental committee = 1, otherwise 0, of firm *i* in year *t*.
FEMALE(17)	Board diversity	Dummy variable: If the percentage of female directors within the board is higher than the industry median =1, otherwise 0, of firm *i* in year *t*.
B_SIZE(18)	Board size	Dummy variable: If the size of the board is higher than the industry median =1, otherwise 0, of firm *i* in year *t*.
B_IND(19)	Board independence	Dummy variable: If the percentage of independent directors in the board is higher than the industry median =1, otherwise 0, of firm *i* in year *t*.
DUALITY(20)	Executive duality	Dummy variable: If the chief executive officer (CEO) and the chairman of the board are different =1, otherwise 0, of firm *i* in year *t*.
EXECOMP (21)	Executive	Dummy variable: If board is incentivised by either bonus, long-

	compensation	term compensation or options =1, otherwise 0, of firm *i* in year *t*.
Control variables		
SIZE(22)	Firm size	Natural logarithm of total revenue of firm *i* in year *t*.
ROA(23)	Financial performance	Return on assets measured as EBIT divided by total assets of firm *i* in year *t*.
LEV(24)	Firm leverage	Ratio of total long-term debt to total assets of firm *i* in year *t*.
TOBINSQ(25)	Innovation capability	Book value of total assets divided by market value of firm *i* in year *t*.
AGE (26)	Age of assets	Ratio of PPE to gross PPE of firm *i* in year *t*.
CAPX(27)	Capital intensity	Capital expenditure divided by sales revenue of firm *i* in year *t*.
ESI(28)	Industry's environmental sensitivity	Environmental sensitive industry: If the firm belongs to any one of five environmentally sensitive industries =1 (two-digit SIC codes of 13, 26, 28, 29, 33), otherwise 0, in year *t*.
LITIGATION(29)	Industry's litigation sensitivity	Litigation sensitive industry: If the firm operates in a high-litigation industry =1 (SIC 2833–2836, 3570–3577, 3600–3674, 5200–5961, or 7370), 0 otherwise, in year *t*.