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Corporate Incentives for Obtaining Higher Level of Carbon Assurance: Seeking Legitimacy or Improving Performance?

Abstract

Purpose - With the growing attention around carbon emissions disclosure, the demand for external carbon assurance on emissions reports has been increasing by stakeholders as it provides additional credibility and confidence. This study investigates the association between the higher level of external carbon assurance and improvement in a firm's carbon emissions. It provides an understanding of corporate incentives for obtaining a higher level of carbon assurance, particularly in relation to carbon performance enhancements.

Design/methodology/approach - Data are collected from 170 US companies for the period 2012-2017, and are analysed using a change analysis. Generalized method of moment (GMM) is used to address endogeneity.

Findings - Following the rationales taken by legitimacy and 'outside-in' management views, our findings reveal that a higher level of carbon assurance (i.e. reasonable assurance) marginally improves firms' carbon performance (i.e. reported carbon emissions). This is consistent with 'outside-in' management view suggesting that a higher level of assurance could be utilised as a tool for accessing more information about stakeholders' needs and concerns, which can be useful in enhancing carbon performance.

Research limitations/implications - Our findings are generalizable to US firms and may not extend to other contexts.

Practical implication – The implication of this study for companies is that a high level of sustainability assurance is a useful tool to access detailed information about stakeholder concerns, of which internalisation can help to marginally improve carbon performance. For policymakers, the insights into and enhanced understanding of the incentives for obtaining carbon assurance can help policymakers to develop effective policies and initiatives for carbon assurance. Considering the possible improvements in carbon performance when obtaining a high level of sustainability verification, governments need to consider mandating carbon assurance.

Oroginality/value – This study extends the existing studies of assurance in sustainability context as well as in carbon context by explaining why companies voluntarily get expensive external verification (i.e. higher level of assurance) of their carbon emissions disclosure. This study responds to calls in the literature for empirical research investigating the association between environmental performance and external assurance with a focus on level of assurance.

Keywords: Carbon performance, levels of carbon assurance, legitimacy view, outside-in management view.

1. Introduction

Due to the growing economic, social, and political concerns regarding carbon footprint that are linked to climate risks, there has been an increasing stakeholder demand not only for carbon emissions disclosure, but also for verified carbon-related information by a third party to minimise information asymmetry between managers and external stakeholders (Ascui & Lovell, 2012; Datt *et al*., 2020). Although carbon emissions disclosure could be mandatory under specific Emissions Trading Schemes (ETSs), the assurance of those disclosures is largely voluntary (Green and Zhou, 2013, Huggins *et al*. 2011). In this regard, the assurance practices on carbon emissions disclosure can vary across different countries and industries, and hence the level of assurance obtained can differ among companies (Green and Zhou, 2013). Nevertheless, these practices are generally argued to improve the credibility of and confidence in environmental disclosure, construct corporate reputation/legitimacy, and reduce information asymmetry (Simnett *et al*., 2009; Jones and Solomon, 2010; Pflugrath *et al*., 2011; Moroney *et al*., 2012; Junior *et al.*, 2014; Cho *et al.*, 2014; Casey and Grenier, 2015; Cohen and Simnett, 2015; Birkey *et al*. 2016). "In the CSR context, the presence of greater situational incentives renders supporting information value relevant only when combined with independent assurance" (Brown-Liburd and Zamora, 2015, p. 91).

Although environmental reporting has significantly increased (KPMG, 2020), it is argued that CSR reporting and its assurance are "still in its infancy" (Tschopp and Huefner, 2015, p. 574), with limited understanding of impacts (Birkey *et al*. 2016). In particular, carbon assurance can enhance the credibility of disclosures that are otherwise suspects of managerial insincerity and façade about corporate performance (Fan et al., 2021). Empirical research on external carbon assurance is argued to be scarce, and lacks common theoretical backgrounds (Hahn *et al*., 2015). Specifically, there is a lack of empirical evidence on the association between carbon performance and external assurance (Hahn *et al*., 2015)[1]. The focus of some recent assurance studies has shifted towards carbon assurance. These few studies mainly addressed the determinants and effects of carbon assurance (see Velt, 2021) because the market for carbon assurance is still in a formative stage (Datt *et al.*, 2018), with no specific focus on the link between carbon performance and carbon assurance. These studies particularly focused on examining carbon assurance practices (Green and Zhou, 2013),

[1] Prior studies have documented the influence of assurance in improving reporting companies' management systems and internal controls - we view these as elements of corporate performance – (O'Dwyer 2011; Edgley et al, 2010). However, the sustainability assurance literature broadly covers the subject matter, hence specific areas such as carbon assurance remain under-researched.

identifying key determinants of the decision to assure and the choice of assurance provider[2] (Zhou et al., 2016), corporate incentives for external carbon assurance (Datt *et al.*, 2018), the effect of legitimacy threats on corporate incentives to obtain carbon assurance (Datt *et al.*, 2019), corporate incentives for the choice of assurance providers (Datt *et al.*, 2020), and the association between carbon information asymmetry and independent carbon assurance (Fan et al., 2021). Furthermore, the literature on levels of assurance[3] suggests a gap in understanding whether the extent of assurance undertaken impacts on the aspect of business performance even though evidence shows that assurance could change internal processes of businesses (Park and Brorson, 2005). Hodge *et al.* (2009) also argued that to have a complete discussion of assurance on CSR reports, a consideration of the levels of formal assurance (limited and reasonable[4]) included in the US attestation standards is needed.

Accordingly, this paper investigates the association between higher level[5] of external carbon assurance and carbon emissions improvement. It aims to explain why companies voluntarily get expensive external verification (i.e. higher level of assurance) of their carbon emissions disclosure. Is it because a higher level of assurance can support the continuous improvement in carbon emissions? An answer to such question can allow the reports' users to make informed decisions.

In this study, we follow the rationales adopted by the legitimacy and outside-in management perspectives to explore firms' possible incentives for obtaining higher level of external carbon assurance[6]. From a legitimacy theory perspective, carbon disclosure and assurance could be employed as a legitimation strategy (Kuruppu and Milne, 2010). The absence of credible carbon

[2] To do so, the authors examine the international GHG assurance market.

[3] Audit/assurance levels are traditional elements of formal engagements that declare the extent to which evidence and disclosure have been examined by assurance providers. Assurance levels are determined by reporting companies due to the understandable cost it incurs and are disclosed in assurance statements (Riviere-Giordano et al., 2018) that are prepared by assurance providers.

[4] Reasonable/high "makes reference to assurance engagement that communicates a high level of sustainability verification—but not absolute, due to limitations of the internal control—and the conclusions are expressed in a positive way". Limited/moderate "makes reference to assurance engagement that communicates a low level of sustainability verification, and the conclusions are expressed in a negative way" (Martinez-Ferrero and Garcia-Sanchez, 2018, p. 972). Generally, the assurance risk associated with the limited level is acceptable, yet higher than the risk associated with the reasonable level (Martinez-Ferrero and Garcia-Sanchez, 2018).

[5] "…the level of assurance indicates the extent and depth of the work the assurance provider will undertake, and therefore, the degree of confidence report users should be able to have in the assured report" (GRI, 2013, p. 11). More companies commission assurance on a limited level but concerns around substantive improvement from overall assurance is called into question (Boiral and Heras-Sazarbitoria, 2020).

[6] It is important to point out that in addition to incentives from level of assurance that this study focuses on, there are other numerous incentives of assurance that have been documented in the literature to varying degrees (See Velt, 2021; Zhou et al., 2016; Manetti and Toccafondi, 2012). The assurance levels are subject to different interpretation that affects the outcome of engagements, including perceived credibility and comfort that influences user judgement. This affects one of the objectives of assurance processes for enhancing stakeholder accountability (Boiral and Heras-Sazarbitoria, 2020), thus an exploration of the impact of the levels of assurance is vital in the development of the practice.

emissions disclosure could be viewed as a sign of ecological irresponsibility, which could negatively affect organisation's legitimacy (Datt *et al.*, 2020). The perceived insufficient reliability of carbon emissions disclosure and associated risk to legitimacy may encourage companies to obtain a higher level of assurance to enhance the disclosure credibility. Such enhanced credibility could positively affect "the societal perceptions of a company's integrity with regard to its accountability" and thus its legitimacy (Braam *et al.*, 2016, p. 726). However, the legitimacy sought by companies around carbon is to advance a green image than improve performance (Fan et al., 2021). In this regard, if a higher level of carbon assurance is purely obtained for legitimation purposes, it might not necessarily coincide with improvements in firm's subsequent carbon emissions (Luo and Tang, 2014).

An alternative perspective is proposed by the 'outside-in' management view which argues that relevant opinions and expectations from external parties – stakeholders – can be implemented in management processes to improve performance. From this perspective, organisations may utilise carbon assurance as an 'outside-in' opportunity for middle management and employees to create performance change. Based on this view, a higher level of assurance (i.e. reasonable assurance) could provide detailed information on stakeholders' norms and expectations about carbon performance which can be implemented in management processes and result in performance improvement. This is irrespective of whether reasonable assurance has been used as a legitimising tool for poor carbon performance. Legitimacy and outside-in perspectives provide different views that can add value to the investigation of carbon assurance and carbon performance. Thus, both rationales are considered in this paper to examine corporate incentives for obtaining a higher level of carbon assurance.

To achieve our aim, we run change analysis on a sample of 170 US firms (total 559 firm-year observations) which assured their scope 1 and scope 2 emissions over the period 2012-2017. During this period, the urgency to manage climate change has been increased (Hörisch, 2013) which led to Paris Agreement signed in 2016. Carbon emissions and assurance information were collected from the Carbon Disclosure Project (CDP). The CDP is argued to be the largest database of carbon emissions data (Green and Zhou, 2013), which provides consistent carbon information for all participating firms (Luo and Tang, 2014) due to the existence of a set of norms to be followed (Datt *et al.*, 2019). The US represents an interesting context for our study because it is the second largest carbon polluter country in the world. US local governments persistently discuss and implement various carbon regulations. They also pressurise firms to employ "industry-sponsored emission-

abatement programs, such as voluntary carbon disclosure and independent verification" (Datt, *et al.*, 2019, p. 183).

Our study has three key contributions to the literature. First, it extends the existing studies of assurance in sustainability context (e.g. Jones and Solomon, 2010; Peters and Romi, 2015; Braam *et al.*, 2016; Martinez-Ferrero and Garcia-Sanchez, 2018; Riviere-Giordano *et al.*, 2018; Sheldon and Jenkins, 2020), as well as carbon context (Green and Zhou 2013; Datt *et al.*, 2018, 2019, 2020). It provides empirical evidence on the relationship between the higher level of assurance and the change in carbon performance to explain why companies voluntarily get expensive external verification (i.e. higher level of assurance) of their carbon emissions disclosure. By investigating this relationship, we also respond to the calls in the literature for empirical evidence on the association between environmental performance and external assurance (Hahn and Kühnen, 2013; Hahn *et al.*, 2015), with a focus on the level of assurance (Hodge *et al.*, 2009). Second, our study is based on two alternative perspectives of corporate social responsibility; namely, legitimacy and 'outside-in' management perspectives. Thus, it contributes to the current literature through empirically testing these perspectives' validity and applicability in the emerging field of carbon assurance. In addition, this study responds to the call in the literature to use legitimacy theory to address the question concerning whether external carbon assurance is only a tool to improve legitimacy or whether it is related to genuine reduction targets (Hahn and Kühnen, 2013; Hahn *et al.*, 2015). Third, this study uses the US as a context. US companies have different tendencies in relation to carbon assurance (Datt *et al.*, 2019), particularly the level of assurance obtained. Although a very limited number of studies focused on carbon assurance in the US context (see, Datt *et al.*, 2019), to our knowledge, no prior studies addressed the relationship between levels of assurance and improvement in carbon performance (i.e. carbon emissions disclosed by firms) using the US as a context.

The remainder of this paper is organised as follows. The next section defines the theoretical background, and develops the hypotheses. Section 3 explains the sample, empirical model, and variables' measurement. Section 4 presents the results followed by the discussion and conclusion in section 5.

2. Theoretical background and hypotheses development

There is an expectation on companies to disclose information beyond the financial state of their performance. This has resulted in 80% of the largest companies, from all regions of the world, actively engaging in formal disclosure of sustainability performance (KPMG, 2020). To this end, there has been increasing concerns from key stakeholders on the quality and reliability of the

disclosures for informed decision making. Environmental issues and in particular, carbon emission maintains a conspicuous role in addressing the urgency of climate related risks (IPCC, 2022). Companies implement a variety of internal procedures to measure and report on the scale of their carbon output. However, the credibility of carbon disclosure remain an issue of concern as the information may be subject to managerial manipulation, greenwashing and capture (Fan et al., 2021). So far, few regulations have directly addressed measures of enhancing carbon disclosure. The International Auditing and Assurance Standards Board (IAASB) outlined guidelines for assuring GHG disclosure (IAASB, 2012) as a response to the demand for increased reliability of corporate carbon emission information through the delivery of an external and independent function by assurance providers (Manetti and Toccafondi, 2012). Assurance engagements are unique as they are based on reporting companies carbon disclosure commonly situated in stand-alone sustainability reports or part of annual reports. Companies voluntarily expresss interest for assurance providers to have their carbon disclosure undergo an assurance process. The major assurance providers can be considered in two distinct groups. The accountant assurance providers are dominated by the Big4 firms and are influential players in assurance market with perceived reputational capital in terms of longevity and scope of experience. Non-accountant assurance providers usually possess valuable specific subject area expertise in the form of consulting and engineering firms (Martinez-Ferrerro et al., 2018). The assurance market accommodates the varying capabilities of the assurance provider groups. As such, there is a continuous debate on the most appropriate basis for determining preference of assurance providers based in their categorised group.

The assurance process largely entails assurance provider interactions with reporting companies and evidence gathering procedures. The availability of audit trails – an area of strength for accountants – as well as technical knowledge expertise around carbon – specialty of certain consultants and engineers – are essential to delivering carbon assurance. In addition, the level of assurance is another key area of consideration as it informs readers on the extent to which the assurance procedure scrutinise the companies carbon processes and initial disclosure. Assurance levels are depicted as limited/moderate or high/reasonable, which dictates how assurance opinions are presented. Limited/moderate level is considered to have negative assurance opinions and are framed as: “Based on our procedures described in this report, nothing has come to our attention that causes us to believe that the selected subject matter stated above presented in the Reports … has not been prepared, in all material respects, in accordance with bp’s Reporting Requirements and Definitions (BP, 2021 p. 57). In contrast, high/reasonable assurance level is viewed as positive assurance opinion within the context of: “In our opinion, the sustainability information presents, in all material respects, a

reliable and adequate view of the policy and business operations with regard to sustainability … in accordance with …. GRI Standards" (Philips, 2021 p. 269). Assurance conducted on limited/moderate level are found to be effective in detecting omissions and errors in sustainability reports (Martínez-Ferrero and García-Sánchez, 2018). The literature has insufficient coverage on the reliability and scope of procedures associated with carbon disclosures on the basis of accounting for climate risks that a high/reasonable assurance could provide which involves scrutiny beyond finding omissions in disclosures. For instance, carbon emissions are commonly disclosed as Scope 1, 2 or 3 with Scope 3 constituting about 70% of businesses's carbon footprint, yet assurance of Scope 3 disclosures are significantly lacking overall.

In order to investigate firms' incentives for obtaining higher level of carbon assurance, we use two alternative views. Following legitimacy theory argument, companies may be motivated to employ a higher level of carbon assurance (i.e. reasonable assurance) as a legitimation tool to gain, maintain and/or repair corporate legitimacy with no real/serious intention towards improving carbon emissions. Following 'outside-in' management view, a higher level of assurance can be used as a tool to pressurise and incentivise firms to enhance carbon emissions. The outside-in view regards reasonable assurance as a tool supporting infiltration of detailed and relevant stakeholders' norms and expectations into firms in order to drive change and improve performance. These two views, which inform our hypotheses, present different arguments on corporate incentives for obtaining a higher level of assurance.

2.1. Assure but do not perform- a legitimacy view

Within the areas of environmental disclosure and responsibility, legitimacy theory has been a highly influential theoretical perspective (Aerts and Cormier, 2009; Mahadeo *et al.*, 2011; Beelitz and Merkl-Davies, 2012). According to the legitimacy perspective, company's activities should be congruent with the norms and values of the society it operates in (Qian and Schaltegger, 2017). At the same time, it is argued that since legitimacy is mostly based on perceptions, it could be controllable by companies (Ashforth and Gibbs, 1990). For companies to be perceived as legitimate, not only the actual operations, but also the society collective perception of those operations plays an important role (Deegan, 2002). As climate change and global warming have increasingly become key political and societal issues, disclosing and assuring carbon information can be viewed as a mechanism to gain stakeholders' support and approval through manipulating or educating them (Qian and Schaltegger, 2017). This is because managing corporate image can be easier compared to making genuine commitments to environmental performance (Neu *et al.*, 1998; Lyon and

Maxwell, 2011; Cho, et. al, 2015) that are viewed as secondary corporate objectives (Kuruppu and Milne, 2010).

From a legitimacy theory perspective, companies tend to obtain carbon assurance when they have concerns about their legitimacy (Datt *et al.*, 2019). Improving the communication with stakeholders through third party validation can help stakeholders understand the non-financial aspects of a business and thus support its sustainability (Datt *et al.*, 2019). Nevertheless, the related/subsequent improvements in the underlying carbon performance remain questionable considering the discretionary/voluntary nature of carbon disclosure, the absence of an internationally recognised protocol, and managerial incentives to manipulate carbon information (Deegan and Rankin, 1996; Kolk *et al.*, 2008; Hahn *et al.*, 2015).

It was found that "the purchase of carbon assurance may be used as a strategy to manage threats to a firm's legitimacy and to reduce the concerns of stakeholders" (Datt *et al.*, 2018, p. 15). Thus, there have been recent calls in the literature to examine the value relevance of external carbon emissions assurance (Datt *et al.*, 2018). Datt *et al.* (2019), using a sample of the largest US firms disclosing their carbon emissions to CDP from 2010-2013, documented that obtaining a voluntary assurance from a third party could act as a legitimising tool strengthening the confidence of stakeholders and enhancing firm's legitimacy. They reported that companies with a higher level of emissions are more likely to obtain independent assurance. Large firms also tend to obtain assurance because of the pressure excreted on them by their large group of stakeholders. As such, companies may use carbon assurance to enhance the usefulness and creditability of emissions information, which could alleviate concerns about legitimacy (Simnett *et al.*, 2009; Datt *et al.*, 2019). However, we still have no understanding of whether the use of such a tool is symbolic or substantive when it comes to carbon performance. We argue that companies might obtain carbon assurance, particularly specific level of assurance as a tool to manage stakeholders' concerns about environmental performance, but might not necessarily improve their subsequent carbon performance. The verification of non-financial reports, particularly in relation to carbon assurance practices, is new, which raises many criticisms and unresolved issues in the literature (Hopwood, 2009; Gray, 2010).

In this regard, we follow Hodge *et al.* (2009) who argued that to have a complete discussion of assurance on CSR reports, a consideration of the levels of formal assurance included in the US attestation standards is needed. These are limited and reasonable assurance (AICPA, 2016). The chosen level of formal assurance, by conveying a favourable picture of a company, might reduce the effects of poor(er) environmental performance. Hodge *et al.* (2009) found that the interaction between the type of assurance practitioner and levels of assurance provided could affect the

confidence of report users in the information provided. Positive expressions of assurance are argued to offer more assurance (Gay *et al.*, 1998). Rivière-Giordano *et al.* (2018) examined whether different levels of assurance statements of environmental disclosures impact investment choices in the French context. Based on an experiment with investors, it was found that when assurance is voluntary and there are at least two levels, firms should avoid selecting the lowest level of assurance because it negatively affects investor decisions. As such, obtaining a higher level of assurance could signal a higher level of credibility in relation to carbon information. In this regard, it could reasonably be expected that companies might obtain a higher level of assurance on carbon disclosure to manage stakeholders' perceptions by providing independent evidence on the congruence between their organisational practices and the norms and values of companies' respective societies. Nevertheless, they might not improve their subsequent carbon performance. Thus, it is crucial to understand whether a higher level of carbon assurance is associated with genuine improvement in carbon performance. Studies examining carbon assurance argue that it is likely to be obtained when companies are concerned about their legitimacy (Datt *et al.*, 2019). However, these studies do not investigate the levels of carbon assurance. In other words, do companies apply a higher level of carbon assurance on carbon emissions disclosure to secure legitimacy without any subsequent improvements in performance? This question remains unanswered and thus this study aims to address it.

Following the legitimacy perspective and the abovementioned critical views, no changes in carbon performance can be expected as a result of obtaining a higher level of carbon assurance. In this regard, obtaining a higher assurance level (i.e. reasonable assurance) for carbon emissions disclosure is viewed as a way to repair or portray sustainable images to obtain/maintain legitimacy and not associated with improvements in carbon performance. Therefore, the following hypothesis can be formulated:

H0: Higher level of assurance (i.e. reasonable assurance) has no impact on firm's carbon performance.

2.2. Assure to perform – 'outside-in' management view

Complete and reliable assurance encourages a wider focus on management processes combined with stakeholder input to produce sound feedback that drives development in management operations (Edgley *et al.*, 2010). In this management-oriented perspective, assurance on carbon emissions disclosure accommodates interaction with stakeholders through 'triangulation of evidence' (Maroun, 2018) provide opportunities for companies to gain increased understanding of

internal functions that can potentially improve carbon performance. Companies gain access to stakeholder expectations and ideas that can feed into performance measures, Schaltegger and Wagner (2006) referred to this as 'outside-in' approach to corporate sustainability. The outside-in approach recognises communication tools that managers use for improving internal corporate performance. The approach supports the adoption of stakeholder expectations and norms into organisational processes to drive performance improvement (Qian and Schaltegger, 2017). Empirical evidence shows that managers are concerned about environmental performance and disclosure (Patten, 2002). It is usual for managers to employ strategies that position themselves positively in the environmental discourse due to the increasing risk of climate change and public pressure. However, companies are more concerned about reputation, perception, brand image, and legitimacy than embracing a real commitment to deliver 'high quality' carbon reporting (Birkey *et al*. 2016; Boiral and Saizarbitoria, 2020; Pitrakkos and Maroun, 2020). Secondary attention to carbon performance measures only suspends associated risks and delays opportunity for effective stakeholder dialogue that can be meaningful in advancing performance.

The 'outside-in' view offers an alternative approach to legitimacy perspective that welcomes the effective utilisation of management tools to inform internal processes with information gathered from external parties. Much of management processes rely on decision making that is mainly driven by internal considerations which have resulted in vast environmental disclosures by majority of corporations around the world but bereft of tangible quality (Michelon *et al.*, 2015) as stakeholders are continuously dissatisfied with attempts to understand, recognise impact and develop clear, consistent strategy on key performance areas. As such, the potential to develop strategic relationships with stakeholders and create value is not harnessed (Jones and Solomon, 2010). 'Symbolic' practices have been used by corporations to manage appearance without improving or adjusting actual performance (Cho *et al.*, 2015). Substantive progress in meeting global carbon targets requires synergy between internal procedures and external stakeholder needs. 'Outside-in' approach to assurance establishes a conduit that channels information needs of stakeholders to internal managers through assurance providers. For instance, the recommendations in assurance statements are useful mechanisms for companies to access stakeholder concerns and improve internal processes (O' Dwyer, 2011). Certain recommendations are 'private' (Edgley *et al.*, 2015), thus assurance providers have room to include a thorough review of performance that could simultaneously benefit management and promote stakeholder views (O' Dwyer *et al.*, 2011).

Assurance within the scope of the outside-in approach motivates companies to perform better as a direct response to stakeholder concerns. There is value in demonstrating stakeholder-related

evidence from assurance processes feeds into corporate decision-making for an opportunity to establish competitive advantage, sustain trust and create originality in communicating with stakeholders. In this regard, the voice of stakeholders is embedded in corporate operations as a feature of innovative reorientation of assurance services in responding to dynamic and competitive market demands (Andon et. al. 2015). The infrastructure of 'outside-in' perspective facilitates efficient and effective expansion of assurance services in carbon performance with an increased confidence in the scope and quality of disclosure that demonstrates commitment to improving performance. Empirical results show that changing carbon emissions disclosure drives changes that lead to improvement in carbon performance (Qian and Schaltegger, 2017). However, questions on the quality of corporate disclosure overall, including carbon-related, within the accounting literature continue to resurface (Cho *et al.*, 2015). So far, there is little empirical evidence on the utilisation of assurance outcome to drive corporate carbon performance.

Assurance levels – limited and reasonable – dictate the degree of scrutiny assurance providers can apply on the scope of assurance engagements which determines the extent of procedures undertaken and their reliability in terms of test undertaking, access to internal controls, involvement of stakeholders, and drawing conclusions (Manetti and Toccafondi, 2012). A reasonable assurance expects assurance providers to collect thorough verifiable evidence from all the procedures in the previous point. The relevance of a reasonable assurance with an outside-in management perspective gives greater opportunity for gathering evidence including issues of concern from stakeholders to reliably inform management. The literature has been calling for wider stakeholder consideration in assurance for some time (Edgley *et al.*, 2010) and empirical evidence shows assurance providers are willing to promote stakeholder perspectives (O' Dwyer *et al.*, 2011). Both features are accommodated within reasonable assurance that can play an instrumental role in the outside-in management view. The literature is unclear on how the outcome of reasonable assurance impacts corporate operations and performance.

Progress on carbon emissions is a principal environmental issue that affects global socio-economic future development. Many countries have developed plans to reduce emissions and major companies across the main sectors have increased carbon risks and reduction disclosures (KPMG, 2020). However, there are significant areas in need of clarity that show the connection between operations, disclosures, and performance improvements with implications on the role of thorough assurance service delivery (O' Dwyer and Unerman, 2020). The outside-in view facilitates assurance provision that management can use to direct focus on areas of improvement. Therefore, based on 'outside-in' management view, the following hypothesis can be formulated as:

H1: Higher level of assurance (i.e. reasonable assurance) has an impact on firm's carbon performance.

3. Research method

3.1. Sample

The analysis of this study is based on carbon emissions and assurance information collected from the CDP data for the years 2012-2017. Panel data allows us to control for unobservable firm heterogeneities in order to have better hypotheses testing. The CDP is a not-for-profit organisation holding the largest database of self-reported climate data from the world's largest companies since 2000. On yearly basis, companies provide information on their carbon emissions, energy use, climate change risk, and opportunities, and other environmental issues by completing a survey sent out by the CDP. Over the last years, CDP data has been increasingly used by several environmental and sustainability studies, such as Kim and Lyon (2011), Luo *et al*. (2012), and Qian and Schaltegger (2017), among others.

We use US companies in the CDP from 2012 to 2017. During this period, the urgency to manage climate change has been increased which leads to the Paris agreement signed in 2016. The aim of the Paris agreement is to strengthen the global response to the threat of climate change by limiting global temperature rise to 2 degrees Celsius above pre-industrial levels for this century. Our focus on US companies is justified by the fact that the US is the second polluter country in the world, and it is expected that US companies reduce their negative impact on climate change by seeking different mechanisms such as external carbon assurance. Furthermore, although a very limited number of studies focused on carbon assurance in the US context (see, Datt *et al*., 2019), to our knowledge, no prior studies addressed the relationship between levels of carbon assurance and improvement in carbon performance (i.e. carbon emissions) used the US as a context.

For the purpose of this study, companies are selected if they: (1) released assurance information to the CDP from 2012 to 2017, and (2) used the same assurance level for both scope 1 and scope 2 in the same year (i.e. either reasonable assurance or limited assurance for both scope 1 and scope 2). Therefore, our initial sample included 221 US companies. Since this study uses change measures of the variables (see section 3.2.2), those companies containing two or more consecutive years of information are included in the final sample. This reduces our sample to 170 US companies (559 firm-year observations). Out of 559 observations, 95 observations belong to the period 2012-2013, 109 observations belong to the period 2013-2014, 106 observations belong to the period 2014-2015,

124 observations belong to the period 2015-2016, and finally, 125 observations belong to the period 2016-2017.

3.2. Empirical model and variables' measurement

3.2.1. Variables' measurement

3.2.1.1. Dependent variable

Carbon performance:

Carbon performance is measured as the carbon emissions intensity ratio. This ratio is calculated by total direct (Scope 1) and indirect (scope 2)[7] emissions obtained from CDP over the period from 2012 to 2017 to total sales (Patten, 2002; Luo and Tang, 2014; Qian and Schaltegger, 2017). Total scope 1 and scope 2 emissions are used as an overall indicator of carbon performance because both scopes are considered an essential part of corporate carbon responsibility and management (Qian and Schaltegger, 2017). Since emissions intensity ratio considers the variation in the output of products and services, it is more comparable across different reporting periods and between firms than the absolute carbon emissions. In addition, such an adjustment for company size is made as larger companies would be expected to have higher environmental impacts than smaller firms (Patten, 2002). Considering that carbon emissions intensity reflects a pollution level of firm, carbon emissions intensity scores are inverted by multiplying them by a negative one to facilitate carbon performance's interpretation. Hence, we reverse the sign of changes in total emissions intensity when we calculate this variable. The higher the scores are, the better the carbon performance.

3.2.1.2. Independent variable

Assurance-level:

Voluntary carbon assurance can reduce the risk of emissions and/or errors in carbon emissions information to an acceptable level. According to the International Standard on Assurance Engagement 3000 (ISAE 3000) of the International Auditing and Assurance Standards Board (IAASB), the level of assurance carried out by assurance providers can vary depending on the amount and depth of work that assurance providers undertake. According to ISAE 3000, there are two levels of assurance namely, reasonable assurance and limited assurance. "Reasonable assurance"

[7] The GHG protocol requires companies to report emissions classified into three scopes. Scope1 is the direct emissions from companies' owned/controlled sources. Scope 2 encompasses the indirect emissions from consuming purchased electricity, heat, and/or steam. Scope 3 includes the other indirect emissions, such as, waste disposal, transportation and outsources activities. As the latter emissions sources differ among companies, Scope 3 was excluded.

reduces the risk of errors and/or omission to a low level, and a "limited assurance" reduces risk to a moderate level. To capture levels of assurance a dummy variable is used where one indicates that reasonable assurance has been obtained for the company's scope 1 and scope 2 emissions and zero shows limited assurance.

3.2.1.3. Control variables

Firm size:

Several studies (e.g. Qian and Schaltegger, 2017; Datt *et al*., 2018; Datt *et al*., 2019) of carbon performance and carbon assurance have used firm size as a control variable. Since large firms are under intensified public scrutiny and media coverage, they may have more incentives to improve their environmental performance. They may do so by investing in clean technologies (Clarkson *et al*., 2011) to reduce social and political costs and to demonstrate that they are good citizens and their activities are legitimate (Datt *et al.*, 2018). The natural logarithm of total assets is used to measure firm size.

Financial performance:

Previous studies (e.g. Ngwakwe and Msweli, 2013; Matsumura *et al.*, 2014; Lewandowski, 2017) have mostly documented a positive relationship between financial performance and environmental performance. From the perspective of resource availability, unlike less profitable companies which may have less financial resources to mitigate carbon emissions, profitable companies have a greater capacity and resources to improve carbon performance. Financial performance is measured as return on assets (ROA).

Financial Risk:

Leverage has been used as one of the determinants of environmental investment decision and/or change in environmental strategy (Clarkson *et al.*, 2011). According to Datt *et al*. (2018, p.8) "climate change is an important risk factor considered by creditors in their lending decision". Disclosing credible and transparent carbon emissions information reduces information asymmetry, and hence "decreasing the cost of renegotiation and monitoring of debt structures; thus, debtholders may get a lower interest rate for their loans" (Datt *et al*., 2018, p.8). This may motivate companies to improve their carbon emissions and also undertake reasonable carbon assurance to reduce creditors' concerns. Financial risk is measured as total debt divided by total assets at the end of the fiscal year.

Liquidity:

Liquidity, which reflects the ability of a company to meet its financial obligations, is expected to positively affect the environmental strategy (Qian and Schaltegger, 2017). De Villiers *et al*. (2011) argue that firms with adequate cash flows tend to allocate more resources to large environmental projects, and hence improve environmental performance. Following Clarkson *et al.* (2011) and Qian and Schaltegger (2017), liquidity is calculated as the net cash flow from operations divided by the total assets at the beginning of the fiscal year.

Sales growth:

Sales growth is another control variable of this study. Sales growth has been employed by several studies to indicate management capability of creating financial value (King and Lenox, 2001). Al-Tuwaijri *et al*. (2004) argue that good managers who are capable of creating financial values accept social and environmental responsibility of the firm and invest in environmental issues to control the firm's environmental pollution. In this study, sales growth is measured as changes in sales divided by beginning period sales.

Asset newness:

Clarkson *et al*. (2011) assert that firms with newer equipment are expected to employ less polluting technologies, and hence have a better environmental performance. Following Qian and Schaltegger (2017, p. 371) asset newness is calculated as "the ratio of net property, plant and equipment (PPE) to gross PPE at the fiscal year-end".

Capital intensity:

Clarkson *et al.* (2008) argue that firms with higher capital expenditure are more likely to invest in newer equipment and environmental developments, and hence achieve better environmental performance. Following Clarkson *et al*. (2008), we measure capital intensity as the ratio of capital spending to total sales revenue at the end of the fiscal year.

Board size:

Goodstein *et al*. (1994) argue that an increase in board size facilitates board involvement in social and environmental-related issues. A larger board can bring more knowledge and experience (Dalton *et al*., 1999), and hence offer better advice on different issues such as environmental performance (De Villiers *et al.*, 2011). Board size is measured by the number of directors.

Board independence:

It is widely accepted that boards with a higher number of independent directors tend to be more effective in monitoring and evaluating social and environmental performance (De Villiers *et al*., 2011). De Villiers *et al*. (2011, p.7) argue "independent boards are more likely to realize the potential of long-term investments in environmental matters and resist any management pressure to overlook such investments". Board independence is measured as the percentage of independent directors to board size.

Environmental exposure:

Firms in environmentally sensitive industries are generally under higher environmental scrutiny and exposure (Aerts and Cormier, 2009). Firms with high environmental exposure may tend more to improve their environmental performance in order to mitigate social and political pressure. Following Qian and Schaltegger (2017, p.371), environmentally sensitive industry sectors include "materials (such as chemicals, construction materials, metals and mining, and paper), energy (such as oil and gas drilling and exploration) and utilities (such as electric, gas and water utilities)". We control for environmentally sensitive industries using a dummy variable that takes a value of 1 when a company belongs to an environmentally sensitive industry and 0 otherwise.

Finally, a dummy variable is used to control for industry and year-fixed effects. The industry and year fixed effects are appropriate because they mitigate the problem of industry and year-specific unobserved heterogeneity that is correlated with the independent variable. Table 1 summarises the variables of this study.

<Insert Table 1 about here>

3.2.2. Empirical models

Following Qian and Schaltegger (2017), change analysis is conducted to identify the relationship between assurance levels and carbon performance changes. According to Qian and Schaltegger (2017, p. 366), "compared to the prevailing levels analysis, change analysis increases the power of tests by examining the causes and consequences of developing environmental strategies and performance". This method was also employed by Clarkson *et al*. (2011) to investigate determinants and consequences of proactive environmental strategies.

To test the hypotheses developed for this study, the following model is constructed:

$$\Delta CP_{it+1} = \alpha_o + \alpha_1 Assurance-level_{it} + \alpha_2 \Delta Firm\ size_{it} + \alpha_3 \Delta ROA_{it} + \alpha_4\ \Delta Financial\ risk_{it} + \alpha_5 \Delta Liquidity_{it} + \alpha_6\ \Delta Sales\ growth_{it} + \alpha_7\ \Delta Asset\ newness_{it} + \alpha_8 \Delta Capital\ intensity_{it} + \alpha_9 \Delta Board\ size_{it} + \alpha_{10} \Delta Board\ independence_{it} + \alpha_{11} Environmental\ exposure_i + \alpha_{12} Industryeffect_i + \alpha_{13} Yeareffect_t + \varepsilon_{it}.$$

In the above model, ΔCP is dependent variable representing the change in total emissions intensity (i.e. scope 1 plus scope 2 divides by sales) for company *i* in year *t+1*. Assurance-level is an explanatory variable of this study representing the level of assurance (i.e. reasonable or limited assurance) for company *i* in year *t*. The lead-lag method is employed as it may provide a better explanation of whether employing different assurance-level by companies (leading) in a preceding year can lead to change (either positive or negative) in carbon performance (lagging) in a subsequent year. All control variables except environmental exposure, industryeffect, and yeareffect capture the changes of the variables for a company *i* in year *t*. Because of using change analysis, six years of panel data (i.e. 2012-2017) effectively generates a five-time period. The next section will cover the results of this study.

4. Results

4.1. Descriptive statistics and correlation analysis

Table 2 and Table 3 indicate carbon emissions and frequency of reasonable and limited assurance by year and industry respectively.

<Insert Table 2 about here>

<Insert Table 3 about here>

Table 2 shows that, on average, 2012 and 2014 have the highest and lowest total emissions intensity respectively. In 2012, firms on average generate 0.352 tonnes of total carbon emissions per thousand dollars of sales revenue, while in 2014 on average 0.247 tonnes of total carbon emissions per thousand dollars of sales revenue have been generated. Table 2 also shows that mean emissions intensity in the sample decreased from 2012 to 2014 and then increased again. This can be explained as result of the decrease in the energy intensity of the economy; changes in fuel mix as a result of the push for less reliance on coal in favour of natural gas (reduced emission discharge); and shifts in consumption patterns (Feng et al., 2015). However, population growth and consumption level continued in an upward trend. It is also argued that adjustments in production structures affecting labour and imports and changes in the types of goods being consumed over time can have a significant effect on emissions levels (Feng et al., 2015). By comparing average total emissions

intensity between 2012 and 2017, we can cautiously conclude that, on average, firms' total emissions intensity has slightly improved over the period of investigation. Table 2 also indicates that the number of firms undertaking reasonable assurance for their total CO2 emissions is almost the same for each year.

Tables 3 indicates total emissions intensity average, and reasonable and limited assurance frequency for each industry. Among all industries presented in Table 3, electric utilities has the highest total emissions intensity average (2.325) while healthcare providers and professional services have the lowest average of total emissions intensity. This table also shows that electric utilities industry has the highest reasonable assurance frequency (28), while healthcare providers, professional services, Telecommunication Services, and Textiles industries have the lowest (0) frequency of reasonable assurance.

Table 4 presents the descriptive statistics of change variables used in the estimation model. The results reveal that the average changes of inversely recorded carbon performance is -0.001 meaning that the average total emissions intensity remains stable despite the fact that firms' size has slightly increased over the period of this study (the mean value of Δ*Firm size* is 0.018). As shown in Table 4, 24.9 percent of our sample firms obtained reasonable assurance for their carbon emissions. Descriptive statistics of control variables show that, on average, changes in ROA are negative (-20.4%) while changes in financial risk (1.7%), capital intensity (21.3%), board size (5.4%), and board independence (33.8%) are positive. Average changes in liquidity, sales growth, and asset newness are close to zero indicating that they remained stable during the period of investigation of this study.

<Insert Table 4 about here>

Table 5 presents the correlations between the variables of this study. Changes in carbon performance and assurance levels are positively correlated suggesting that obtaining reasonable assurance marginally improves a firm's carbon emissions. Changes in ROA and liquidity are positively and significantly correlated with changes in carbon performance. This is consistent with our expectation that firms with better financial performance have a greater capacity and resources to improve carbon performance. Table 5 shows that all the correlation coefficients are lower than 0.6300, indicating that the multicollinearity level is acceptable (Anderson *et al.*, 2013).

<Insert Table 5 about here>

4.2. Hypotheses testing

Table 6 reports our main findings based on pooled OLS regression analysis. Model 1 reports the baseline model where control variables are regressed on dependent variable (i.e. changes in carbon performance). The coefficient for ΔROA is significant and positive ($\beta = 0.0027$, $p < 0.1$). This is consistent with our expectation and in line with previous studies (Lewandowski, 2017; Matsumura *et al*., 2014; Ngwakwe and Msweli, 2013) that profitable firms have a better capacity and resources to improve carbon performance. Model 2 reports the estimates where assurance-level and control variables are regressed on changes in carbon performance. The coefficient for assurance-level is positive and significant ($\beta = 0.0265$, $p < 0.1$). Hence, hypothesis 2 is supported. This means that obtaining reasonable assurance for carbon emissions disclosure marginally improves a firm's carbon performance (i.e. lower carbon emissions will be reported by firms in the following year). The result supports 'outside-in' management view suggesting that external carbon assurance establishes a conduit that conveys information needs of stakeholders to internal managers through assurance providers. In other words, the collective outcome of reasonable assurance processes – including, but not limited to, evidence collection, analysis, findings, recommendations, assurance statements, and management letters – serve as useful mechanisms for companies to access stakeholder concerns and improve internal processes (O' Dwyer, 2011). Since reasonable assurance allows assurance providers to thoroughly examine carbon operations and evidence, leading to a robust set of recommendations, managers have a better understanding of stakeholders' concerns, and hence are better equipped to improve carbon performance. Such findings can be considered as good news for proponents of external carbon assurance and proponents of improved corporate environmental performance.

<Insert Table 6 about here>

4.3. Address endogeneity: Generalized method of moment (GMM)

We argue that two-way causality (simultaneously) may exist between carbon performance and level of carbon assurance. In other words, it is not just level of carbon assurance that may impact firm's carbon performance, but firm's carbon performance may also impact corporate decision on dopting different levels of carbon assurance. For instance, firms with poor carbon performance in one year may choose to apply higher level of assurance (i.e. reasonable assurance) to gain/maintain legitimacy or improve carbon performance in the following year. Hence, we address this issue by estimating the model using generalised method of moments (GMM) approach. This analysis indicates whether the results reported in the section 4.2 are sensitive to alternative model estimations,

and whether they are subject to endogeneity bias. GMM approach mitigates model estimation bias with regards to unobserved heterogeneity, simultaneity and dynamic endogeneity (Ullah et al., 2018; Bhattacharyya and Rahman, 2020).

Following Wintoki et al. (2012) and Addessi et al. (2017), we apply two-step dynamic GMM estimator to our panel data to control for two-way causality (simultaneously) that may exist between carbon performance and level of assurance. Table 7 presents the two-step system GMM results. Consistent with the main results presented in Table 6, there is a positive and significant relationship between level of carbon assurance and carbon performance. This suggests that applying reasonable carbon assurance (i.e. higher level of carbon assurance) positively and significantly improves carbon performance. The results for control variables improved significantly compared with the main results since majority of control variables are significantly correlated with change in carbon performance.

<Insert Table 7 about here>

5. Discussion and conclusion

With a rapid increase in firms' carbon emissions disclosure, there has been a growing demand to verify such disclosure by a third party to enhance its credibility. However, since external carbon assurance is voluntary and costly, the question is why companies voluntarily get expensive external verification of their carbon emissions disclosure. Is it because external carbon assurance can support the continuous improvement in carbon emissions or can create a specific/different image of the organisation to reduce social and political pressure? A limited number of studies focused on examining carbon assurance practices (Green and Zhou, 2013), corporate incentives for external carbon assurance (Datt *et al.*, 2018), the effect of legitimacy threats on corporate incentive to obtain carbon assurance (Datt *et al.*, 2019), and corporate incentives for the choice of assurance providers (Datt *et al.*, 2020). However, previous studies have not investigated corporate incentives for obtaining different assurance levels in relation to carbon performance enhancement. Hodge *et al.* (2009) argued that to have a complete discussion of assurance on CSR reports, a consideration of the two levels of formal assurance (i.e. limited and reasonable assurance) included in the US attestation standards is needed.

Therefore, this study investigated the relationship between a higher level of carbon assurance and improvement in firms' carbon performance (i.e. carbon emissions disclosed by firms). Following the rationales taken by legitimacy and 'outside-in' management views, and using a change analysis of 170 US companies and their carbon emissions and levels of carbon assurance data released

between 2012 and 2017 (total 559 firm-year observations), we find that a higher level of carbon assurance (i.e. reasonable assurance) marginally improve firms' carbon performance (i.e. carbon emissions in the following year). This confirms a tendency for corporations to move from seeking legitimacy (symbolic) to real carbon reductions and improving carbon performance (substantive). Previous results on carbon assurance suggest that carbon assurance could be used as a strategy to manage threats to companies' legitimacy and to reduce stakeholders' concerns (Datt et al., 2019; Datt et al., 2018). Our results provide evidence that companies are taking actions by utilising the insights from reasonable assurance to counter the negative effect of its operation on the environment, which demonstrates concern about climate change.

In the context of environmental reporting, Braam *et al.* (2016) found, based on unreported tests and consistent with legitimacy theory view, that companies with significant amounts of GHG emissions are more likely to purchase external assurance compared to companies with better performance to enhance the credibility of their environmental disclosure and build legitimacy. Similarly, Birkey *et al*. (2016) found that CSR report assurance is highly related to higher assessments of companies' environmental reputation. On the other hand, in the context of corporate sustainability, Braam and Peeters (2018) indicated that companies with higher corporate sustainability performance are more likely to obtain sustainability assurance compared to companies with lower sustainability performance. The authors' results also showed no significant relationship between corporate sustainability performance and the level of assurance chosen. Similarly, Dutta (2020) showed that companies with superior environmental performance in terms of greenhouse gas emissions and water consumption obtain external assurance on their sustainability reports. Such external assurance is also found to enhance the quality of voluntary environmental disclosures for assured companies compared to unassured companies (Moroney et al., 2012). This shows a positive impact of environmental assurance only on the credibility of the report.

Our result takes the above existing results a step further by showing that, in the carbon context, incentives to enhance carbon performance are associated with the level of the assurance obtained (reasonable here). It also shows that the management of companies utilise and benefit from the costly reasonable assurance in terms of carbon performance enhancements. Our result is thus consistent with 'outside-in' management view and shows that insights from reasonable assurance (including the ideas and expectations of stakeholders) help companies to improve performance. Such evidence can provide some basis to inform and probably affect the perceptions of the different levels of assurance (Sheldon and Jenkins, 2020).

In this regard, companies can position themselves as responsible members of society that take climate change risks seriously by using the information gathered from a reasonable assurance to plan and develop robust strategies on carbon emissions. The result confirms the intention of companies in taking active steps towards reducing carbon from operations and an opportunity to implement real measures that advance stakeholder accountability. This position aligns with Business Ambition for 1.5 degrees Celsius, calling for companies to develop ambitious science-based emission cutting targets towards the net-zero objective. As of April 2021, 474 leading companies have signed the commitment to make business models compliant with the targets and avert the disastrous consequences of climate change (UNGC, 2021).

This study has a number of implications and recommendations for policy makers and firms' management. For policymakers, the insights into and enhanced understanding of the incentives for obtaining carbon assurance can help policymakers to develop effective policies and initiatives for carbon assurance, particularly in ways that guide companies and stakeholders to benefit from engagement that creates value for both parties (Jones and Solomon, 2010). Considering the possible improvements in carbon performance when obtaining a high level of sustainability verification suggested by our study, goverments need to consider mandating carbon assurance. This is an important finding considering the recent concerns about the significant impact of climate change on ecosystems, biodiversity, and human systems and the potential further increase in global surface temperature raised by the Intergovernmental Panel on Climate Change (IPCC) (2022). For managers, our findings will help improving the current carbon management practices. Particularly, they may impact management's decision in relation to the level and depth of assurance obtained for carbon emissions disclosure especially if there is real interest in advancing carbon-related performance from operations. Our results suggest that reasonable assurance can be a useful tool for companies to access detailed information about stakeholder concerns, and hence internalise those concerns to improve carbon performance. Such a position could allow companies to face the underlying challenges of disclosure quality (Michelon *et al*. 2015) with greater confidence. It would be also in line with COP26 (2021) recommendation that private sector commitments must not be greenwashing, and credible implementation and monitoring is crucial.

It is relevant to consider the caveats of this study. Firstly, Our findings are generalizable to US firms and may not extend to other contexts. Secondly, although CDP provides one of the most comprehensive carbon data, many companies are unable to accurately collect and disclose carbon emissions. Furthermore, the assurance exercise remains inaccessible to most businesses due to the cost and availability of assurance providers. Finally, although lagging was a useful tool in our

change analysis, we acknowledge that implementation of assurance recommendations might take more than one year depending on the scale of required changes and degree of commitment by corporate hierarchies. This has not been examined in our study due to limited data coverage.

We propose two avenues for future research. Firstly, an extensive survey of managers can be conducted to explore how they perceive different levels of assurance in relation to legitimacy and performance. An expansion on this could also focus on how managers respond to recommendations from assurance, and the processes of developing a strategy on climate risks. Secondly, future studies may also consider focusing on key stakeholder groups' expectations of carbon assurance and perceptions of different assurance levels. These suggestions are expected to enrich the carbon assurance literature because they allow an investigation of the views of both managers and stakeholders.

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Table 1
Summary of variable measurements

Variables	Measurement
Δ Carbon performance (-)	(Total scope 1 and scope 2 divided by sales) multiply by -1.
Assurance-level	'1' is for reasonable assurance and '0' is for limited assurance.
ΔFirm size	Natural logarithm of total assets.
ΔROA	Return on assets.
ΔFinancial risk	Total debt divide by total assets at the end of the fiscal year.
ΔLiquidity	Net cash flow from operations divided by the total assets at the beginning of the fiscal year.
ΔSales growth	Changes in sales divided by beginning period sales.
ΔAsset newness	Net property, plant and equipment (PPE) divided by gross PPE at the end of the fiscal year
ΔCapital intensity	The ratio of capital spending to total sales revenue at the end of fiscal year.
ΔBoard size	Number of directors.
ΔBoard independence	The percentage of independent directors to board size.
Environmental exposure	'1' represents high environmentally-exposed industries and '0' otherwise.

Table 2
Summary of carbon emission intensity and assurance levels by year

Year	N	Total emissions intensity (mean)	Reasonable assurance Frequency	Limited assurance Frequency
2012	102	0.352	30	72
2013	119	0.321	34	85
2014	122	0.247	30	92
2015	137	0.269	32	105
2016	138	0.330	28	110
2017	162	0.317	34	128

Table 3

Summary of carbon emission intensity and assurance levels by industry

Industry	N	No. of companies	Total emissions intensity (mean)	Reasonable assurance Frequency	Limited assurance Frequency
Aerospace and Defense	34	6	0.042	6	28
Air Freight Transportation and Logistics	29	5	0.382	19	10
Air Transportation - Airlines	10	2	0.940	4	6
Automobiles and Components	17	3	0.046	6	11
Banks, Diverse Financials, and Insurance	19	8	0.008	1	18
Building Products	7	3	0.436	4	3
Chemicals	42	10	0.763	4	38
Consumer Durables, Household and Personal Products	31	8	0.104	5	26
Containers and Packaging	14	6	0.194	1	13
Electric Utilities & Independent Power Producers & Energy Traders	41	12	2.325	28	13
Electrical Equipment and Machinery	35	10	0.044	9	26
Food and Beverage Processing	60	18	0.071	17	43
Food and Staples Retailing	10	3	0.044	4	6
Forest and Paper Products - Forestry, Timber, Pulp and Paper, Rubber	14	7	0.277	3	11
Healthcare Equipment and Supplies	5	1	0.277	4	1
Healthcare Providers & Services, and Healthcare Technology	2	2	0.001	0	2
Hotels, Restaurants and Leisure, and Tourism Services	33	9	0.412	5	28
Media	7	4	0.008	2	5
Mining	16	4	0.977	12	4
Oil and Gas	22	8	0.614	10	12
Pharmaceuticals, Biotechnology and Life Sciences	58	14	0.028	9	49
Professional Services	1	1	0.001	0	1
Real Estate	39	10	0.083	7	32
Retailing	47	12	0.032	1	46
Semiconductors and Semiconductors Equipment	20	7	0.042	1	19
Software and Services	58	18	0.030	5	53
Technology Hardware and Equipment	41	13	0.031	11	30
Telecommunication Services	21	5	0.092	0	21
Textiles, Apparel, Footwear and Luxury Goods	9	2	0.029	0	9
Tobacco	16	3	0.027	6	10
Trading Companies and Distributors	21	6	0.591	3	18
Water Utilities	1	1	0.296	1	0

Table 4

Descriptive statistics for firms from the period 2012-2017

Variable	Obs	Mean	Std. Dev.	Min	Max
Δ Carbon performance (-)	559	-0.001	0.146	-2.158	1.255
Assurance-level	559	0.249	0.433	0	1
ΔFirm size	559	0.018	0.073	-.222	0.664
ΔROA	559	-0.204	4.453	-21	21
ΔFinancial risk	559	0.017	0.083	-.405	1.403
ΔLiquidity	559	0.001	0.042	-.198	.291
ΔSales growth	559	0.006	0.151	-.614	.883
ΔAsset newness	559	-0.006	0.037	-.269	.217
ΔCapital intensity	559	0.213	4.509	-34	32
ΔBoard size	559	0.054	1.298	-5	6
ΔBoard independence	559	0.338	5.725	-24	49

Firm Size is log of total assets. Assurance-level is dummy variable where one indicates reasonable assurance and zero indicates limited assurance.

Table 5

Pairwise correlations

Variables	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)	(9)	(10)	(11)	(12)
(1) Δ Carbon performance (-)	1.000											
(2 Assurance-level	0.060	1.000										
	(0.156)											
(3) ΔFirm size	0.035	0.025	1.000									
	(0.415)	(0.553)										
(4) ΔROA	***0.105***	-0.002	0.058	1.000								
	(0.013)	(0.954)	(0.172)									
(5) ΔFinancial risk	-0.008	-0.053	***-0.138***	-0.046	1.000							
	(0.844)	(0.214)	***(0.001)***	(0.278)								
(6) ΔLiquidity	***0.080***	***-0.001***	***-0.159***	***0.152***	***-0.073***	1.000						
	(0.059)	***(0.986)***	***(0.000)***	***(0.000)***	***(0.085)***							
(7) ΔSales growth	***-0.130***	0.029	-0.055	-0.009	***0.110***	***-0.190***	1.000					
	(0.002)	(0.495)	(0.194)	(0.828)	***(0.009)***	***(0.000)***						
(8) ΔAsset newness	-0.015	0.016	***0.306***	0.007	0.012	***-0.164***	***0.087***	1.000				
	(0.717)	(0.710)	***(0.000)***	(0.875)	(0.783)	***(0.000)***	***(0.039)***					
(9) ΔCapital intensity	***-0.081***	-0.010	-0.057	-0.057	***0.081***	***-0.101***	***0.116***	***0.150***	1.000			
	(0.056)	(0.818)	(0.179)	(0.180)	***(0.054)***	***(0.017)***	***(0.006)***	***(0.000)***				
(10) ΔBoard size	0.062	-0.053	***0.154***	0.003	-0.026	0.014	-0.050	***0.090***	-0.012	1.000		
	(0.146)	(0.215)	***(0.000)***	(0.935)	(0.546)	(0.735)	(0.239)	***(0.033)***	(0.782)			
(11) ΔBoard independence	0.014	0.038	0.049	***0.097***	0.023	***0.135***	-0.045	-0.054	0.050	0.056	1.000	
	(0.739)	(0.365)	(0.244)	***(0.021)***	(0.588)	***(0.001)***	(0.288)	(0.205)	(0.236)	(0.183)		
(12) Environmental exposure	-0.062	***0.217***	-0.041	***-0.088***	-0.006	-0.042	0.038	0.005	***0.099***	-0.063	0.056	1.000
	(0.144)	***(0.000)***	(0.331)	***(0.038)***	(0.883)	(0.321)	(0.372)	(0.913)	***(0.020)***	(0.136)	(0.185)	

The level of significance is given in brackets. Significant coefficients ($p < 0.1$) are highlighted in bold italics.

Table 6
Pooled OLS Regression Results

	Δ Carbon performance (-) Model 1	Δ Carbon performance (-) Model 2
Assurance-level		**0.0265***
		(0.0160)
ΔFirm size	0.0288	0.0258
	(0.0931)	(0.0929)
ΔROA	**0.0027***	**0.0026***
	(0.00141)	(0.00141)
ΔFinancial risk	0.0493	0.0569
	(0.0760)	(0.0760)
ΔLiquidity	0.1090	0.1020
	(0.158)	(0.158)
ΔSales growth	**-0.0846****	**-0.0861****
	(0.0430)	(0.0429)
ΔAsset newness	-0.1690	-0.1700
	(0.185)	(0.185)
ΔCapital intensity	-0.0017	-0.0015
	(0.00142)	(0.00142)
ΔBoard size	0.0049	0.0051
	(0.00481)	(0.00481)
ΔBoard independence	-0.0001	-0.0001
	(0.00109)	(0.00109)
Environmental exposure	**-0.2330****	**-0.2390****
	(0.0944)	(0.0940)
Industry effects	Yes	Yes
Year effects	Yes	Yes
Constant	-0.0105	-0.0247
	(0.0841)	(0.0843)
N	559	559
R^2	13.3%	13.8%
F-statistics p-value	0.002	0.001

Note: Standard errors in parentheses. *** *p<0.01,* ** *p<0.05,* * *p<0.1.* Firm Size is log of total assets. Assurance-level is dummy variable where one represent reasonable assurance and zero represents limited assurance. Environmental exposure is dummy variable where one is for high environmentally-exposed companies and zero otherwise.

Table 7
Two-step system GMM

	Δ Carbon performance (-) System GMM	Std. err.
L. Δ Carbon performance (-)	**-0.2278*****	0.0023
Assurance-level	**0.0111*****	0.0009
ΔFirm size	**-0.0433*****	0.0050
ΔROA	**0.0016*****	0.0001
ΔFinancial risk	**0.0538*****	0.0041
ΔLiquidity	**0.2175*****	0.0080
ΔSales growth	**-0.0850*****	0.0017
ΔAsset newness	**0.0274*****	0.0063
ΔCapital intensity	-0.0001	0.0000
ΔBoard size	**0.0062*****	0.0003
ΔBoard independence	**-0.0013*****	0.0000
Environmental exposure	**-0.0154*****	0.0011
Constant	**-0.0008***	0.0004
Number of observation	367	
AR(1) test p-value	0.032	
AR(2) test p-value	0.615	
Hansen J test p-value	0.605	

Note: *** *p<0.01,* ** *p<0.05,* * *p<0.1.* Firm Size is log of total assets. Assurance-level is dummy variable where one represent reasonable assurance and zero represents limited assurance. Environmental exposure is dummy variable where one is for high environmentally-exposed companies and zero otherwise.