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# The effect of DEFRA guidance on greenhouse gas disclosure

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ABSTRACT

This paper investigates the effect of the 2009 guidance of the Department for Environment, Food & Rural Affairs on greenhouse gas (GHG) disclosure. The sample comprises 215 companies from a population of London Stock Exchange FTSE 350 companies over four years (2008–2011). To quantify GHG disclosure, a research index methodology is employed, with information derived from several GHG reporting frameworks. The econometric model is estimated using panel fixed effects. Our findings suggest that the publication of the 2009 guidance has had a significant effect on the level of GHG disclosure, and that corporate governance mechanisms (board size, director ownership, and ownership concentration) also affect the extent of GHG information disclosure. The results also indicate that companies increased their disclosures prior to the 2009 guidance in anticipation of its publication. These results have important implications for the government, suggesting that non-mandatory guidance could increase disclosure as much as do mandatory requirements.



## 1. Introduction

A growing wave of scientific evidence relating to global warming has significantly influenced policy makers to take decisive steps towards managing greenhouse gas (GHG) emissions (e.g. Boston & Lempp, 2011; Intergovernmental Panel on Climate Change, 2001, 2007; Jones et al., 1988; Karl et al., 1991). Responding to this emerging threat, the United Kingdom (UK) government introduced a set of initiatives known as the Climate Change Programme (Wordsworth & Grubb, 2001). In part, these initiatives led to the enactment of the Climate Change Act (CCA) 2008. Among other things, the CCA (2008) recognises that measuring and reporting GHG emissions is critical to the fight against global emissions, with Section 83 requiring the government to issue guidance on this.[1] The UK government – through the Department for Environment, Food & Rural Affairs (DEFRA) – therefore issued guidance on GHG emissions measurement and reporting in September 2009.

The main aim of the 2009 guidance,[2] which was voluntary, was to support UK organisations in reducing their contribution to climate change. Modelled on the GHG Protocol (2004), the guidance outlined the measurement and reporting criteria for

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[1] Section 83 of the CCA (2008) states: '(1) The Secretary of State must publish guidance on the measurement or calculation of greenhouse gas emissions to assist the reporting by persons on such emissions from activities for which they are responsible. (2) The guidance must be published not later than 1st October 2009. (3)The Secretary of State may from time to time publish revisions to guidance under this section or revised guidance. (4) Before publishing guidance under this section or revisions to it, the Secretary of State must consult the other national authorities. (5) Guidance under this section and revisions to it may be published in such manner as the Secretary of State thinks fit'.

[2] The guidance has since been replaced by a similar guidance 'Environmental Reporting Guidelines: Including mandatory greenhouse gas emissions reporting guidance', published by DEFRA in June, 2013.

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GHG emissions (DEFRA, 2009), and was aligned with other voluntary GHG reporting frameworks, such as International Organization for Standardization (ISO) 14064-1, a specific standard that details accounting and reporting for GHG emissions. Although other GHG reporting guidance (e.g. GHG Protocol, 2004; Global Framework for Climate Risk Disclosure; Carbon Disclosure Project, 2011; Carbon Disclosure Standard Board; Global Reporting Initiative; ISO 14064-1) already existed, the publication of the government-backed DEFRA guidance in 2009 brought momentum and policy clarity to UK companies. This suggestion is consistent with Bowen and Wittneben (2011), who argued that while businesses can measure and report emissions voluntarily, government-backed initiatives such as regulation provide a reasonable basis upon which firms can justify investments in new technologies and other green energy initiatives.

The publication of the DEFRA guidance towards the end of 2009, however, meant that companies wishing to report in accordance with the guidance would have done so for the first time in 2010.[3] Notwithstanding this, it is anticipated that the effect of the DEFRA guidance could also be seen in the period immediately prior to its publication, since firms might have wished to disclose more GHG information in anticipation of the guidance. This is because the CCA (2008), signalling the issuance of the guidance, may have influenced firms to increase their disclosures as a way of pre-empting the guidance requirements. In essence, the staggered approach taken to the introduction of the guidance (i.e. beginning with the CCA, 2008 and then consultations) meant that companies had time to begin experimenting with the disclosure requirements.

In this paper, we investigate whether firms have responded positively to the 2009 DEFRA guidance by disclosing significantly more GHG information over a four-year period (i.e. 2008–2011), with a particular focus on whether more disclosures were made in the two-year period after the issuance of the guidance (2010 and 2011) compared to the two-year period before it (2008 and 2009) – and, if so, whether the voluntary reporting policy architecture adequately enables policy makers to bring about their desired outcome. Evidence of the efficacy of voluntary guidance in influencing disclosure behaviour is important because proponents of regulation argue that without it, organisations lack incentives to voluntarily disclose adequate information; opponents, meanwhile, assert that it is only through market forces that optimal disclosure levels are achieved (Gore, 2004). Investigation of the effect of the 2009 DEFRA guidance is also important since its issuance by the government appears to be an exception rather than the norm. This is on the basis that the regulatory regime governing information disclosure in the UK has followed the English law tradition that only principles are laid down and the rest is supplemented by managerial discretion (Arnold & Matthews, 2002). The 2009 guidance is an exception in that it gives a detailed account (and even illustrations) of how companies should measure and disclose GHG emissions.[4] Thus, the findings of how this exceptional 2009 DEFRA guidance is observed by companies on a voluntary basis may influence government policy in future on whether to issue mandatory requirements or guidance on important disclosure issues.

The study also seeks to establish whether GHG disclosure is determined by corporate governance mechanisms, controlling for company-specific characteristics. This is in part motivated by the 2009 DEFRA guidance requiring that once GHG are measured and disclosed, the organisation should analyse its carbon emissions, the disclosure actions it will take to reduce emissions, and the corporate governance structures in place to manage these. The suggestion that corporate governance structures should be in place to manage GHG emissions implies that such structures may also influence disclosure of GHG information.

Despite the burgeoning research on climate change and GHG disclosure (e.g. Ascui, 2014; Berthelot & Robert, 2012; Freedman & Jaggi, 2005; Kolk, Levy, & Pinkse, 2008; Liao, Luo, & Tang, 2014; Milne & Grubnic, 2011; Peters & Romi, 2012; Prado-Lorenzo, Rodriguez-Dominguez, Gallego-Alvarez, & Garcia-Sanchez, 2009; Rankin, Windsor, & Wahyum, 2011; Stanny, 2011), there is still a paucity of studies focussing on the role of corporate governance in GHG emission disclosures. Furthermore, Milne and Grubnic (2011) made an urgent call for research that looks at a diverse range of climate change accounting, including disclosure. A similar call was made by Ascui (2014), who notes that the social and environmental accounting field has insufficiently addressed most areas of carbon accounting, of which GHG disclosure is one part. Therefore, this study also partly responds to those calls. Following prior studies in particular, that by Kock, Santalo, and Diestre (2012) – we use stakeholder-agency theory, as developed by Hill and Jones (1992), to help explain how corporate governance helps to align managerial and stakeholder interests regarding GHG emission disclosure. This theoretical paradigm, which extends the boundaries of principal – agent relationships as envisaged by agency theory, helps to highlight or justify the extension of the fiduciary duties of the board of directors to cover stakeholders other than shareholders (Berrone & Gomez-Mejia, 2009; Kock et al., 2012).

Our results indicate an increasing trend in GHG disclosures from 2008 to 2011, but a particularly significant increase is evident between 2009 and 2010, implying that the issuance of DEFRA guidance in 2009 on how to measure and report GHG emissions had a positive effect on GHG disclosure. The increase in GHG disclosure between 2008 and 2009, prior to issuance of the DEFRA guidance, could be attributed to firms' anticipation of the issuance of the guidance through the CCA (2008) and

[3] This is due to the specialised nature of GHG emissions, which requires investment in systems and personnel in order to collect, measure, and report such information (see Kolk et al., 2008); therefore, such investment would take time.

[4] Under the DEFRA guidance (2009), firms are encouraged to calculate emissions from activities they control (both direct and indirect carbon footprints), then to categorise them into three 'scopes' (with measurement determined by multiplying activity data by emission factors provided by the authorities), and finally to disclose total emissions (expressed in $CO_2e$ tonnes) and the measurement criteria/standard used. The organisation then carries out a strategic analysis of its carbon emissions, and discloses actions taken to reduce them and corporate governance processes introduced to manage them, including the opportunities available (e.g. emissions trading schemes). Finally, the guidelines call for disclosure of carbon-related risks – both physical (e.g. the impact of climate change on company operations) and regulatory (e.g. the potential effect of carbon regulation on company operations).

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the subsequent consultations. The results also suggest that governance mechanisms (board size, director ownership, and ownership concentration) and company-specific control variables (size, gearing, financial slack and industry) have a significant effect on GHG disclosure.

The research makes the following contributions to the disclosure literature. First, the study provides evidence of the effect of the government-backed 2009 DEFRA guidance on GHG reporting. The evidence of the effect of this guidance is important since the existing literature argues that voluntary disclosure often indicates the extent to which mandatory guidelines may enforce compliance (Hess, 2008). This is especially important given that GHG reporting became mandatory for all London Stock Exchange-listed companies for reporting years ending on or after 30th September 2013. As one of the policy instruments intended to help the UK achieve its emission targets, our review of its effect also contributes to Milne and Grubnic's (2011, p. 951) argument that the slowdown in achieving meaningful progress in attaining some international commitment targets such as Kyoto is perhaps in part due to 'continuation of relatively weak policy regimes' in this area. Our finding that government-backed guidance produced positive results might strengthen the need for firm government intervention in those other initiatives, which are largely voluntary.

Second, our study contributes to the understanding of the extent of GHG voluntary disclosure practices by UK firms in the context of the requirements of a number of pieces of GHG disclosure guidance. A broader but GHG-focused and inclusive index enables us capture the effect of the 2009 DEFRA guidance prior to its issuance, since it is not specific to this guidance. In contrast with the GHG disclosure indexes used by most extant research (e.g. Freedman & Jaggi, 2005; Liao et al., 2014; Peters & Romi, 2012; Rankin et al., 2011; Stanny, 2011) which are mostly based on only one set of GHG disclosure guidance – i.e. the Global Reporting Initiative (GRI, 2006) – or on Carbon Disclosure Project (CDP) disclosures, our GHG disclosure draws on a number of guidance documents such as the GHG Protocol (2004), Global Framework for Climate Risk Disclosure (2006), ISO 14064-1 (2006), and DEFRA (2009). The use of a single and generic environmental disclosure guidance such as GRI (2006) to measure a specific issue, e.g. GHG disclosure, has come under criticism (see Day & Woodward, 2009; Rankin et al., 2011), who regard it as being too broad yet too limited to help adequately in quantifying GHG disclosures. On the other hand, the reliance on CDP data has also come under scrutiny, with the reliability of such data being questioned since firms tend not to disclose their information related specifically to climate change (Kolk et al., 2008). Moreover, in the earlier period of the questionnaire (i.e. 2003–2005), there were inconsistent questions, which makes comparison difficult.

Third, our focus on companies from a diverse range of industries sets this study apart from prior GHG disclosure studies, which have tended to focus predominantly on the so-called 'environmentally sensitive' industries. A wide focus, such as that adopted here, enhances the understanding of the subject matter (De Villiers, Naiker, & Van Staden, 2011). Finally, our study also contributes by providing evidence of the role of corporate governance and company-specific control variables on GHG disclosure in the UK, where there is limited empirical evidence (Liao et al., 2014).

The paper is structured as follows – Section 2 presents the literature review and hypotheses development; and Section 3 describes the research design. Empirical results of the research are then discussed in Section 4, while the summary and conclusions are presented in Section 5.

## 2. Literature review and hypotheses development

### 2.1. Theoretical framework

Existing research has used agency, stakeholder, and legitimacy theories (Berthelot & Robert, 2012; Freedman & Jaggi, 2005; Llena, Moneva, & Hernandez, 2007; Stanny & Ely, 2008) to explain the rationale behind environmental (including GHG) disclosure. Deegan (2002) argued that often there is an overlap between the various theories explaining disclosure, and so it is not uncommon to use more than one theory. Following the work of Hill and Jones (1992), and in particular Kock et al. (2012), we use the stakeholder-agency theory paradigm to analyse the effect of governance and other external control mechanisms, such as government-initiated reporting guidance (e.g. DEFRA, 2009), in influencing firms to report GHG emissions.

Stakeholder-agency theory presents a firm as a nexus of contracts between resource holders and seekers (Hill & Jones, 1992). Thus, beyond the agency theory arguments, this paradigm argues that in a modern day firm, managers are deemed to have an implicit relationship with not only shareholders but also other stakeholders (Blair, 1998; Kock et al., 2012). De Villiers and Van Staden (2011a) explained that managers' reporting of environmental information is thus targeted not only at shareholders but also at other non-capital market stakeholders. What makes managers duty-bound to explain themselves to these stakeholders through disclosure is the need to have continued access to critical resources that might be controlled by the latter (Hill & Jones, 1992). It is this mutual resource dependency that gives stakeholders other than shareholders a legitimate claim on a firm's allocation of resources, including those related to voluntary disclosure (De Villiers et al., 2011; Kock et al., 2012). Therefore, within the stakeholder-agency framework, the principal–agent relationship is extended to mean a relationship that exists between a manager and stakeholders (Hill & Jones, 1992; Kock et al., 2012).

Just as in agency theory, however, the principal–agent relationship envisaged in the stakeholder–agency relationship is riddled with a conflict of interests regarding how the firm's resources are allocated. Kock et al. (2012) argued that management and stakeholder interests may diverge, in particular regarding environmental issues, with stakeholders showing a greater preference for environmental issues than managers. In fact, there is a growing number of studies that have documented evidence of various stakeholders pressurising a firm to be environmentally friendly (Bansal, 2005; Darnall,

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Henriques, & Sadorsky, 2010; Sharma & Henriques, 2005). Two reasons for the divergence of managers' and stakeholders' interests regarding environmental issues have emerged. First, this divergence is caused by the nature of the investment required in environmental initiatives, which is often significant in the short term but has long-term returns in most cases (Darnall et al., 2010; King & Lenox, 2002; Marcus & Fremeth, 2009). It is this long-term nature that conflicts with managers' interests, which in most cases have a short-term horizon often tied to or mirrored in their employment contracts. Second, it is believed that other than shareholders, stakeholders have no direct vested interest in financial returns; hence, their pressure for more environmental initiatives will not be hindered by considerations relating to the impact of environmental initiatives on the firm's margin (Kock et al., 2012). Nonetheless, existing evidence showing the positive impact of environmental performance on a firm's financial performance may help align managerial and stakeholder interests regarding environmental and climate change initiatives, but perhaps only to a certain level. Generally, it is expected that a strong preference for environmental or green initiatives exhibited by other stakeholders would stretch to the point at which environmental performance brings positive returns to financial performance and pushes a firm towards the negative zone, and managers would strive to resist that (Kock et al., 2012).

In addition, it is not only the desire to limit the negative impact of environmental initiatives on financial performance that makes managers resist environmental initiatives. Apart from the substantial investment needed in the complex redesign of a firm's internal processes and the development of green competencies (King & Lenox, 2002; Marcus & Fremeth, 2009), it also requires managers to invest significant time in thinking about and planning the systems. Nonetheless, Berrone and Gomez-Mejia (2009) stated that managerial efforts in this respect are often unobservable and non-verifiable; hence, they may not be rewarded through existing compensation schemes. Therefore, as argued by Kock et al. (2012), this leads management to have a different utility function from other stakeholders. The anonymity of the managerial effort could potentially create an information asymmetry problem, leading to managers not being rewarded for these efforts, as most of their compensation relates to financial performance.

Prior evidence indicates that managers prefer financial growth-related projects, as these are often linked to their compensation, job status, and security (Hill & Jones, 1992), and that in certain cases they do delay investments in research and development with long-term benefits that will be realised after their contracts have expired. In these circumstances, the principals (stakeholders) face a situation where the agent might begin to act in conflict with their interest due to the information asymmetry problem if the latter is inadequately motivated. Therefore, this phenomenon creates the need to develop mechanisms to monitor managerial interests and to align them with those of other stakeholders regarding environmental or GHG emission issues. Kock et al. (2012) suggested that within the framework of stakeholder-agency theory, mechanisms to monitor and align managerial interests could be achieved through external means (such as stakeholder pressure through government regulation/guidance) and internal mechanisms (such as corporate governance).

Arguably, external control mechanisms could help align the interests of managers with those of other stakeholders regarding GHG emission-related issues. Kock et al. (2012) argued that government regulation or guidance provides a legitimate basis for other stakeholders to impose their wishes on management. More importantly for managerial decision-making, government guidance potentially creates a decision-making dilemma. First, De Villiers and Van Staden (2011a) explained that the availability of such guidance, or of various voluntary reporting regimes such as those on GHG emissions, provides a compliance platform that symbolises a firm's environmental efforts. Second, Kock et al. (2012) reasoned that the existence of such reporting frameworks significantly increases the chances of managers being held personally responsible or accountable for any environmental misbehaviour if compliance is enforced. Support for regulation also rests on the premise that 'regulation of reporting reduces accounting choice; leads to more consistent and comparable reporting; and thereby reduces information asymmetry' (De Villiers & Van Staden, 2011b, p. 319).

In this respect, there is growing evidence that faced with such situations, managers or firms strive to stay ahead of the game by disclosing information in advance when a regulation or a move towards compulsory regimes is signalled by the authorities. De Villiers and Van Staden (2011a) argued that government intervention through various types of legislation also adds momentum to a firm's adoption of voluntary initiatives relating to good management of the environment, citing the introduction of the Energy Policy Act 2005 in the USA, which gave many companies the incentive to adopt proactive policies on the environment. More important to the UK setting is the finding by De Villiers and Van Staden (2011b) that in the UK almost 50% of shareholders supported a move towards prescribed regulation on environmental information disclosure. Rankin et al. (2011) attributed the increase in GHG disclosures by Australian firms over time to public and policy pressure. Other voluntary disclosures have also demonstrated an increasing trend as a result of public policy pressure (Guthrie & Parker, 1989) and community concerns (Deegan, Rankin, & Tobin, 2000). Inchausti (1997) found that in Spain, legislation – even before becoming compulsory – had a strong bearing on the voluntary accounting disclosures made by companies. It is in this context that the effect of the issuance of the 2009 DEFRA guidance on GHG disclosure is investigated in this paper.

Corporate governance is considered an effective internal mechanism to help align and monitor managerial interests. Corporate governance is regarded as 'the determination of the broad uses to which organisational resources are displayed and various stakeholder conflicts are resolved' (Daily, Dalton, & Cannella, 2003, p. 371). Kolk and Pinkse (2010) argued that this inclination signifies rather a departure from the widely held view of governance as comprising resolutions and being simply a tool to bridge managerial and shareholder interests. Milnes (2009) and Deloitte (2011) both argued that liberation of the governance sphere beyond the traditional role means that other concepts, such as corporate social responsibility and environmental management, are now within the remit of board responsibilities.

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According to Luo (2005) and Maier (2005), this now means that corporate governance involves a relationship between a company and its stakeholders, and that it is the outcome of these relationships that determines strategic direction and firm performance. Rodrigue, Magnan, and Cho (2013) explained that since the board of directors is responsible for a firm's governance, the directors are responsible for formulating policies relating to environmental issues. Wang and Dewhirst (1992) noted that directors were becoming increasingly aware of their role in relation to multiple stakeholders. Rossouw (2005) stated that taking responsibility for firms' impact on societies and their stakeholders is a governance requirement from the stakeholder perspective. Indeed, according to Hill and Jones' (1992) proposition of stakeholder-agency theory, the board of directors is tasked to control an organisation's sustainable behaviour and to ensure that the firm is accountable to various stakeholders (see Brennan & Solomon, 2008, for further discussion on this).

In this case, it is expected that board members strive to achieve the right balance between the competing interests of these stakeholders (Ingley & Van der Walt, 2001) and that their accountability is seen through environmental and social information reporting, (Healey, 2003; Perrini & Tencati, 2006; Solomon, 2010) as an extension of their fiduciary duties. Indeed, the existing literature is unequivocal in its stand that company directors have fiduciary duties to stakeholders and the environment (Haniffa & Cooke, 2005; Kolk, 2008; Milnes, 2009). Therefore, where managers are seen to have inclinations towards priorities other than or at the expense of environmental initiatives, board members may intervene to help align the interests of managers with those of the stakeholders. McNulty and Pettigrew (1999) argued that when managers have misguided priorities for reasons known only to them, inquisitive directors can question such motives and help to align managerial initiatives with shareholder expectations. Therefore, in developing the hypotheses, we discuss how various characteristics help a board to meet its responsibilities, particularly relating to GHG voluntary reporting. De Villiers et al. (2011) argued that depending on how a board is structured, it can perform two functions: monitoring and resource provision.

The literature has identified a number of corporate governance characteristics that help a firm perform these functions relating to voluntary disclosures. These include board composition and size, the presence of non-executive directors (NEDs), CEO duality, audit committee, and audit firm. Beasley, Carcello, Hermanson, and Lapides (2000) found the presence of NEDs on the board to be crucial in preventing management fraud, and thereby protecting shareholder interests. The board of directors is also meant to champion transparency and accountability, which is essential in disclosures (Collier & Zaman, 2005).

### 2.2. Prior studies

Empirical evidence suggests that every time a reporting regulation/set of guidance or significant milestone related to the environment and climate change is reached, companies reflect their reaction through disclosure. For instance, Freedman and Jaggi (2010) documented evidence that ratification of the Kyoto protocol in 2005 made companies whose jurisdiction had ratified the protocol increase their level of GHG emission disclosure. Similarly, Rankin et al. (2011) found that the presence and adoption of ISO 14001-certified environmental management systems had a significant impact on the extent and quality of GHG disclosures by Australian companies. The guidelines proposed by the Canadian Institute of Chartered Accountants had a similar influence on the disclosure pattern of Canadian companies, as reported by Berthelot and Robert (2012). In other disclosure studies, similar evidence has been documented (see Canace, Caylor, Johnson, & Lopez, 2010; Heflin, Kross, & Suk, 2012).

Studies of GHG disclosures particularly focussing on corporate governance characteristics have included that by Prado-Lorenzo and Garcia-Sanchez (2010), who investigated the role of the board of directors in divulging relevant GHG information in a sample of FTSE Global 500 companies that participated in the CDP 2008 survey. The disclosure index was developed from the Carbon Disclosure Leadership Index. Their results partly indicated that although firms are under public pressure to disclose GHG information, the board of directors sometimes discourages these disclosures if there is a high probability of litigation, especially when the costs of disclosure outweigh the benefits. Their results also suggested that while the business environment has changed over time with the influence of other stakeholders increasing, as far as climate change-related information is concerned, the board has continued to maintain the tradition of prioritising shareholder interests.

In another study focussing on which attributes of corporate governance influence a firm to make GHG disclosures, Peters and Romi (2012) examined the determinants of GHG voluntary reporting in a sample of firms participating in the CDP from 2002 to 2006 and found evidence that GHG disclosures were positively related to what they called 'sustainability oriented corporate governance mechanisms', notably the presence of a board-level environmental committee and of a management-level post of corporate sustainability officer. The size of the board and expertise of its members and the sustainability officer were dominant characteristics of those firms that disclosed more GHG information. Knowledge synergies between the environmental committee and the audit committee were also found to be a significant element in increasing the likelihood of voluntary GHG disclosures.

Galbreath (2010) investigated how well governance structures by both US and non-US firms had enabled firms to respond to the challenge of climate change, using 98 firms in three industries across ten countries. Overall, the study found that the firms were underperforming in their governance responses towards climate change but noted that non-US firms had a better governance score than their US counterparts, using the Ceres scoring methodology. In addition, board characteristics such as board size and diversity (including female representation) had no statistical link to climate change disclosures, while directors' age had some influence, with younger directors exerting positive influence. A recent study by Liao et al. (2014) found that gender diversity, together with board independence and the existence of a board-level environmental committee, influences the extent to which a firm is transparent in its ecological actions. Other studies have generally focused on the

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growing trends in disclosures and their underlying determinants (e.g. Berthelot & Robert, 2012; Freedman & Jaggi, 2005; Prado-Lorenzo et al., 2009; Stanny, 2011; Stanny & Ely, 2008).[5]

### 2.3. Research hypotheses

#### 2.3.1. DEFRA guidance

The rationale for expecting DEFRA's (2009) guidance to significantly affect GHG disclosure is that companies would be keen to demonstrate their green efforts before further government intervention through enforceable regulation (see Watts & Zimmerman, 1986). Besides, according to stakeholder-agency theory, external mechanisms (such as reporting guidance) may help to align managerial and shareholder interests. Patten (1992) and Deegan et al. (2000) also documented evidence of firms increasing their level of voluntary environmental disclosure in response to increased public pressure or a particular event. Llena et al. (2007) stated that every time there was a significant milestone related to the environment and GHGs – such as the Kyoto Protocol or European Commission recommendation on measuring and reporting environmental information in annual reports – interest in this activity increased among European Union-based firms. Inchausti (1997) found that in Spain, legislation (even before it came into full effect) had a strong bearing on the voluntary accounting disclosures made by companies. Rankin et al. (2011) attributed the increase in GHG disclosure by Australian firms over time to public and policy pressure, and noted the significant influence of ISO 14001 on the extent and quality of environmental reporting; and Gordon, Loeb, and Zhu (2012) found that the enactment of the Sarbanes-Oxley Act 2002 positively affected voluntary disclosure of firms' security activities. We would therefore expect GHG disclosures in the UK to have increased over the years, but in particular after DEFRA's guidance was issued in 2009. Hence, we hypothesise:

H1 *There is a positive relationship between the publication of DEFRA's guidance and GHG disclosure*, ceteris paribus.

#### 2.3.2. Corporate governance

*2.3.2.1. Board size.* According to stakeholder-agency theory, the board is vital to monitoring managerial actions, with a view to aligning these with stakeholder interests (Hill & Jones, 1992; Walsh & Seward, 1990). However, the appropriate board size to discharge these duties satisfactorily is unclear, although the growing consensus is that a large board is likely to be beneficial in providing resources, particularly counsel and advice (De Villiers et al., 2011). Large boards have a diverse range of experience and skills that may enable them to discharge their duties more effectively (Dalton, Daily, Johnson, & Ellstrand, 1999). This diversity means that different board members may represent different interests, including those regarding environmental and GHG issues. Moreover, Booth and Deli (1996) argued that the uncertainty relating to environmental issues generally leads to large board sizes in order to allow firms' access to the expertise necessary to overcome this uncertainty. In addition, De Villiers et al. (2011, p. 1645) stated that larger boards give wider connections with important stakeholders, so that firms with large boards are 'likely to facilitate access to critical financial resources, allowing such boards more financial leeway to pursue environmental initiatives'.

Peters and Romi (2012) found evidence of a significant positive relationship between board size and GHG disclosure. Other disclosure studies that found a positive association include those by Cormier, Ledoux, Magnan, and Aerts (2011) for environmental disclosure in general; Cerbioni and Parbonetti (2007) for intellectual capital; Akhtaruddin, Hossain, Hossain, and Yao (2009) for voluntary disclosure in Malaysia; and Allegrini and Greco (2013) for voluntary disclosure by Italian listed companies. Considering the theoretical and empirical evidence, we hypothesise:

H2 *There is a positive relationship between board size and GHG disclosure*, ceteris paribus.

*2.3.2.2. Non-executive directors.* Board members are ultimately tasked to monitor and evaluate the performance of the CEO and executive management (Akhtaruddin et al., 2009; Fama & Jensen, 1983). According to provision B1.2 of the UK Combined Code 2012, companies in the UK are encouraged to have more NEDS than executive directors on their boards as a way of enhancing board independence and improving board efficiency. This monitoring extends beyond financial issues and also covers a diverse range of areas such as environmental and climate change, since these also have grown in strategic

[5] Notwithstanding a few studies discussed above, it is recognised that empirical research on climate change accounting, of which this study is part, is a growing field; notable contributions and progress have been made in this respect. The *Accounting, Auditing & Accountability Journal* special issue on climate change accounting research, published in 2011, comprised papers from interdisciplinary perspectives but all related to climate change; this was a testimony of climate change accounting research coming of age. In this edition, Milne and Grubnic (2011) provided a useful summary of this field, and the need for further research has been emphasised. Besides, a recent review by Ascui (2014), in which articles published in at least five of the top journals on environmental accounting from 2008 were reviewed, showed that a total of 89 articles had been published, 15 of which had exclusively focused on carbon disclosures. For a useful summary of various avenues for research in this area, see Milne and Grubnic (2011). Another useful review of literature is provided by Stechemesser and Guenther (2012).

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importance to merit the attention of the board (De Villiers & Van Staden, 2011a; De Villiers et al., 2011). The monitoring is important because executive management is always faced with a conflict of interest when making decisions on matters with benefits that will outlive the managers' contracts. Thus, CEOs may not be motivated to invest in environmental or climate change systems with unclear short-term benefits. On the other hand, prior studies (Kock et al., 2012; Prado-Lorenzo & Garcia-Sanchez, 2010) have argued that an independent board, mostly made up of NEDs, is capable of resisting management pressure to sideline these environmentally friendly initiatives. The role of independent directors in influencing management implementation of decisions such as those relating to financial disclosure is well documented in the literature (Mangena & Tauringana, 2007). More important to our setting, the role of NEDS in influencing environmental and climate change disclosures has also been documented (Post, Rahman, & Rubow, 2011). It is believed that the need to protect their own reputation and manage relationships with other environmentally sensitive stakeholders may give NEDs the incentive to champion the need for climate change disclosures. It could also be the case that NEDs do not feel the pressure of competitors to the same extent as executive managers (Prado-Lorenzo & Garcia-Sanchez, 2010). In view of this, we hypothesise:

H3 *There is a positive relationship between the proportion of NEDs on the board and GHG disclosure*, ceteris paribus.

*2.3.2.3. Director share ownership.* According to Kock et al. (2012), the divergence of interests regarding climate change issues between directors and shareholders may occur due to information asymmetry. Director share ownership therefore helps to align the interests of directors and shareholders (Dalton et al., 1999; De Villiers et al., 2011). Directors who own shares have a strong influence on the type of information communicated to outsiders, because they are fully aware that the latter use this to judge their performance. Connelly, Certo, Ireland, & Reutzel (2011) explained that director ownership – especially where executive directors have a significant stake – motivates them to act in the interests of a broader constituency of stakeholders. When interests are aligned, consensus might easily be reached on environment-related projects with potential long-term benefits (De Villiers et al., 2011; Hansen & Hill, 1991). In addition, it is reported that director ownership improves board monitoring of strategic decisions, including about environmental and climate change issues (Westphal, 1999). Johnson and Greening (1999) argued that increased managerial ownership increases the probability of managers being sympathetic to social and environmental activities, as they deem them potentially able to create goodwill, thus inducing customers to be more favourably disposed to their companies' products, which will in turn improve the companies' standings with other stakeholders such as bankers, government, and investors.

In contrast, some argue that increased director ownership may lead to aberrant decision-making by executive directors (e.g. Dunn, 2004). Mohd Ghazali (2007) argued that when substantial investment is expected or required to be made in systems to enable a firm to discharge social and environmental responsibilities, and there is uncertainty as to the payback possibility of such investment, managers with high share ownership may resist voluntary activities, including disclosures. The studies of Mohd Ghazali and Weetman (2006) and Ahmed Haji (2013) found director share ownership to be negatively associated with disclosure. Therefore, considering the litigious nature of GHG emission, which may make stakeholder reaction to disclosure unpredictable, we argue that director ownership may lead to a cautious approach to disclosure, thereby bringing about low disclosures. We therefore hypothesise:

H4 *There is a negative relationship between director share ownership and GHG disclosure*, ceteris paribus.

*2.3.2.4. Ownership concentration.* Separation of ownership and control often leads to information asymmetries that, if unchecked, are exploited by managers for their own benefit, at the expense of shareholders (Jensen & Meckling, 1976). Thus, ownership structure is considered part of the governance that helps monitor managerial behaviour. Nonetheless, monitoring becomes difficult when ownership is dispersed, due to the 'free rider' problem, with managers taking advantage of their freedom and benefiting themselves at the expense of others. It is argued that block holding (or high concentration of ownership) means stakes are high should managers make a mistake or act irrationally; the owners are therefore expected to have resources for (and a special interest in) monitoring management behaviour (Noe, 2002; Shleifer & Vishny, 1986). Shleifer and Vishny (1986) argued that large blockholders (often with a significant resource base) are more likely to absorb monitoring costs than are individual shareholders. Besides, as agency theory suggests, monitoring has costs that may eventually be passed onto managers through contractual arrangements. Hence, with high ownership concentration, managers may have incentives to disclose more as a way of minimising the information asymmetry and the subsequent monitoring costs.[6]

[6] Others have warned that where blockholders have aligned themselves with managers (and so are privy to the information available to them), they might have less incentive to push for more disclosure (Bushman & Smith, 2001). Thus, blockholders' alignment with managers undermines the former's monitoring responsibility and often results in a conflict of interests with other groups, such as minority shareholders. In this respect, high ownership concentration is considered detrimental to voluntary disclosure (see Chau & Gray, 2002; Matolcsy, Shan, & Seethamraju, 2012). Berthelot and Robert (2012) found a positive relationship between widely held ownership and voluntary disclosure of climate change information by Canadian oil and gas companies. Brammer and Pavelin (2008) found that UK firms with high ownership concentration disclosed less environmental information, both quantitatively and qualitatively.

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Due to increased scrutiny by various parties and the risk associated with climate change, we expect high ownership concentration to play a crucial role in forcing managers to disclose more information on GHG emissions as a way of safeguarding their investments. The fact that institutional investors have collaborated through initiatives that provide a platform for firms to disclose their GHG information (such as the CDP) means their presence within an organisation may influence managers to lead by example and so make more GHG disclosures. We therefore hypothesise that:

H5 *There is a positive relationship between ownership concentration and GHG disclosure*, ceteris paribus.

*2.3.3. Control variables*

We control for a number of underlying company-specific characteristics that could influence the extent of GHG disclosure. First, company size is a proxy for a number of things, such as public visibility: large companies tend to attract the attention of diverse stakeholders, who use intense pressure and scrutiny to force them to engage in other social and environmental activities as a way of maintaining their legitimacy within their operating environment (Branco & Rodrigues, 2008; Stanny & Ely, 2008). The majority of studies have found a significant positive relationship between company size and GHG disclosure (e.g. Berthelot & Robert, 2012; Chithambo, 2013; Freedman & Jaggi, 2005; Hackston & Milne, 1996; Peters & Romi, 2012; Prado-Lorenzo et al., 2009; Rankin et al., 2011; Stanny, 2011). Our measure of company size is the natural log of total sales. Second, we control for gearing (measured as a ratio of total debt to total shareholders' equity), considered a measure of risk exposed by both equity holders and debt holders. In essence, creditors are worried that if a highly geared company is not properly monitored, there might be wealth transfer from them to shareholders. In this case, if not provided with adequate information, creditors find their own means of monitoring management behaviour.

Third, our study controls for firm profitability (measured by return on assets), because theoretical and empirical evidence suggests that profitability is an indicator of a firm's efficiency in resource allocation, meaning managers could be motivated to provide more information about their profitability and other areas of stakeholder interest as a way of attracting more capital than the less profitable firms (Brammer & Pavelin, 2008). Fourth, we control for liquidity (current assets divided by current liabilities), because Cooke (1989) argued that highly liquid companies are likely to disclose more information in order to set themselves apart from firms struggling with liquidity, and hence to attract favourable business-transaction terms. Other controls include financial slack, capital expenditure (capex), and firm age. We introduce financial slack (measured as cash and cash equivalents, divided by total sales). Firms with financial slack are expected to channel resources into environmental or climate change initiatives, including disclosure (Kock et al., 2012).

In line with other prior studies, such as De Villiers et al. (2011), we also control for the status of a firm's capital equipment in property, plant, and equipment – since those with newer equipment are considered to have the capacity to manage their emissions better than those with older equipment. This is represented by dividing total capital expenditure by total sales (capex) (De Villiers & Van Staden, 2011a). In addition, firm age is also considered to be a factor that could affect the extent of GHG disclosure. Older firms are deemed well enough established to have resources to manage climate change issues, in contrast to younger ones, which might have other pressing issues. Firm age is measured as the natural log of the number of years a firm has been publicly listed on the London Stock Exchange. Finally, following de Villiers et al. (2011) and Liao et al. (2014) we also controlled for industry.

## 3. Research design

### *3.1. Sample selection*

In order to test the hypotheses and meet the research objectives, our target population comprised companies listed on the UK FTSE 350 from 2008 to 2011. The FTSE 350 was chosen because it is broad enough to cover a wide range of industries and it comprises big companies that may set the pace on GHG reporting. Brammer and Pavelin (2006) suggested that the use of large companies in a diverse range of industries permits a comprehensive review of disclosure and reasonable generalisability of results. The period 2008–2011 was chosen because it covers two years before and after the publication of DEFRA's 2009 guidance.

Financial-sector firms (including banks, insurance companies, investment trusts, unit trusts and real-estate companies) – of which there were 93 – were excluded from the sample because they are subject to different disclosure and statutory requirements that may affect their accounting policies, disclosure decisions and corporate governance structures (Mangena & Tauringana, 2007). Also excluded (to ensure comparability of the results) were firms with unpublished annual reports and/or data missing from DataStream and elsewhere (e.g. as a result of deletions following mergers and acquisitions). Finally, companies were excluded if there were not listed for the entire period of study or were subsidiaries of others already represented in the sample. This left a total sample of 215.

### *3.2. GHG disclosure measure*

To quantify GHG disclosure, we developed an index of disclosure comprising 60 items of information based on the requirements of several GHG reporting framework. The validity and suitability of the research index – which is broader and more comprehensive than those used in previous studies, e.g. Prado-Lorenzo et al. (2009) had a checklist of only 19 items –

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**Table 1**
Variable measurement description.

| Symbol | Full name | Measurement |
|---|---|---|
| $Y_{it}$ | GHG disclosure index | Disclosure score expressed as a ratio of the total possible score, i.e. 60 |
| $x^{defra}$ | DEFRA | Dummy variable coded 1 for 2010 and 2011, or 0 for 2008 and 2009 |
| $x^{bs}$ | Board size | Number of people making up the board of a company |
| $x^{ned}$ | NEDs | Ratio of NEDs on the board |
| $x^{do}$ | Director or insider ownership | Proportion of shares held by directors |
| $x^{ow}$ | Ownership concentration | Proportion of ownership by shareholders with 3% or more |
| $x^{s}$ | Company size | Total assets expressed as natural log |
| $x^{gea}$ | Gearing | Ratio between total debt and total shareholders' equity |
| $x^{roa}$ | Profitablity | Profit after tax, divided by total assets |
| $x^{liq}$ | Liquidity | Current assets, divided by current liabilities |
| $x^{fage}$ | Firm age | Firm age expressed as a natural log of the period the company has been listed on the London Stock Exchange |
| $x^{fslack}$ | Financial slack | Measured as cash and cash equivalents, divided by total sales |
| $x^{capex}$ | Capital expenditure | Total capital, divided by total sales |
| $x^{ind}$ | Industry | Dummy variable coded 1 if in environmentally sensitive industry, otherwise 0 |

was reviewed and confirmed by two independent academics experienced in disclosure index-based studies. We then employed a content-analysis technique (widely used in disclosure studies – Hossain, Tan, & Adams, 1994; Mangena & Tauringana, 2007) to quantify GHG disclosure from companies' annual reports and stand-alone environmental/sustainability reports. The literature suggests that disclosure can be quantified on either a weighted or an unweighted basis; Gray, Kouhy, and Lavers (1995) claimed that the choice does not materially alter the results. Freedman and Jaggi (2005), while using a weighted disclosure index, also used an estimated score of disclosed information based on the authors' perception of the contributions of the information items to the evaluation of a firm's global warming performance. Meanwhile, Prado-Lorenzo et al. (2009) used a binary variable (1 or 0, depending on whether the item was disclosed or not), arguing that subjectivity was otherwise a major challenge and that their study (which also considered internet reports and website information) was better suited to this approach. An unweighted approach was considered more appropriate for this study, in which no greater importance is given to any specific user groups (Cooke, 1989; Hossain et al., 1994) or items of disclosure.

A company was awarded a score of 1 if an item was disclosed, and 0 if not, but was not penalised if the item did not apply. The total disclosure index score was then captured for each sample company as a ratio of the total disclosure score, divided by the maximum possible disclosure for the company, and was finally expressed as a percentage.

### 3.3. Econometric modelling

Due to the panel time-series nature of the data, the study employed a fixed effects modelling technique, to help capture variation across different agents in space, and changes over time (Baltagi, 1995; Inchausti, 1997). More importantly, this technique enables the researcher to take into account omitted or unobserved variables, and to control unobserved heterogeneity among companies. The static model of panel data is as follows:

$$Y_{\mathrm{it}} = \alpha_i + x'_{\mathrm{it}}\beta + \mu_{\mathrm{it}}$$

($Y_{it}$ is the endogenous variable (GHG disclosure index); $x_{it}$ are all the exogenous variables; $\beta$ is a set of vector parameters; and $\mu_{it}$ is a random variable.)

From the basic panel fixed model, a number of estimations can be derived. One that resembles an Ordinary Least Squares dummy variable model is a two-way fixed effects model, estimated as follows:

$$Y_{\mathrm{it}} = \alpha_i + \gamma_t + x'_{\mathrm{it}}\beta + \mu_{\mathrm{it}}$$

($\gamma_t$ represents the (fixed) time effects.)

This model gives both the group-specific dummies and time dummies. In our sample, in order to proceed to the specific time effects, all the variables were included, with the exception of 'DEFRA' (i.e. whether before or after DEFRA's 2009 guidance, scoring 0 for 2008 and 2009, and 1 for 2010 or 2011). When the variable 'DEFRA' was included with the years, there was a great degree of multicollinearity, and hence it was decided to drop it. Removing one original variable from the subsequent set of stepwise or other regressions does not affect the final outcome when the two models are compared for fitness. The final models were therefore estimated as follows:

$$Y_{it} = \alpha_i + \beta^{\mathrm{defra}}\cdot x_i^{\mathrm{defra}} + \beta^{\mathrm{bs}}\cdot x_i^{\mathrm{bs}} + \beta^{\mathrm{ned}}\cdot x_i^{\mathrm{ned}} + \beta^{\mathrm{do}}\cdot x_i^{\mathrm{do}} + \beta^{\mathrm{ow}}\cdot x_i^{\mathrm{ow}} + \beta^{s}\cdot x_i^{s} + \beta^{\mathrm{gea}}\cdot x_i^{\mathrm{gea}} + \beta^{\mathrm{roa}}\cdot x_i^{\mathrm{roa}} + \beta^{\mathrm{liq}}\cdot x_i^{\mathrm{liq}} + \beta^{\mathrm{fage}}\cdot x_i^{\mathrm{fage}} + \beta^{\mathrm{fslack}}\cdot x_i^{\mathrm{fslack}} + \beta^{\mathrm{capex}}\cdot x_i^{\mathrm{capex}} + \beta^{\mathrm{ind}}\cdot x_i^{\mathrm{ind}} + \mu_i \ldots\ldots > \text{Model 1}$$

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$$Y_{it} = \alpha_{it} + \beta^{bs}\cdot x_{it}^{bs} + \beta^{ned}\cdot x_{it}^{ned} + \beta^{do}\cdot x_{it}^{do} + \beta^{ow}\cdot x_{it}^{ow} + \beta^{s}\cdot x_{it}^{s} + \beta^{gea}\cdot x_{it}^{gea} + \beta^{roa}\cdot x_{it}^{roa} + \beta^{liq}\cdot x_{it}^{liq} + \beta^{fage}\cdot x_{i}^{fage} + \beta^{fslack}\cdot x_{i}^{fslack} + \beta^{capex}\cdot x_{i}^{capex} + \beta^{ind}\cdot x_{it}^{ind} + \Sigma^{4}\alpha_{t} + \mu_{it} \ldots\ldots > \text{Model 2}$$

$$t = 1$$

where: $i$ is 1, … …215, $t$ is 1 (2008), 2 (2009), 3 (2010), 4 (2011), and $\alpha_t$ are intercept variables that change from year to year. They capture the difference between years, assuming the individual sample members are homogeneous. All other variables are defined in Table 1 below:

We use the Times 1000 industry categorisation, based on environmental risks. Also adopted by Thompson (1998), this groups industries into two (perceived as having a high environmental risk or not).

## 4. Empirical results

### 4.1. Descriptive statistics – dependent variable

The trend descriptive statistics for the extent of GHG disclosure from 2008 to 2011 are presented in Table 2. These show that the mean disclosure for 2008 is 25%, with a minimum of 0% and maximum of 78%, indicating wide variation in the amount of GHG that companies disclose. Disclosures increased to 31% in 2009, presumably because companies took the CCA (2008) as a signal of the government's intention to make GHG disclosure compulsory. GHG disclosure increased significantly between 2009 and 2010, from a mean of 31% to one of 35%.

The descriptive statistics for 2010 show a minimum disclosure of 2% and a maximum of 88%. It is possible that some of the increase in disclosure in 2010 may be attributable to the fact that DEFRA published its guidance in 2009; this suggestion is supported by the fact that in 2010 about 19.5% of the companies sampled disclosed the use of this guidance in compiling and reporting their information. Although the trend in GHG disclosure continued upwards, the increase in mean GHG disclosure between 2010 and 2011 (from 35% to 39%) was lower than between 2009 and 2010 (from 31% to 35%). An equally significant increase in GHG disclosure between 2008 and 2009 – from a mean of 25% to one of 31% – could be due to the effect of the CCA (2008) in signalling the intention to publish guidance on GHG disclosure. This is consistent with Ascui and Lovell (2011), who note that although convergence of a diverse range of stakeholder pressures (e.g. from government, non-governmental organisations, and professionals) has influenced change towards corporate behaviour favouring climate change, anticipation of future regulation is in itself a dominant driver.

The small increase two years after introduction could be explained in terms of some firms catching up with reporting trends. Based on the pooled data (2008–2011), the results indicate that companies' GHG scores ranged from 0 to 88%, but that overall the mean disclosure for the four years is 32%, an indication that the extent of GHG disclosures by FTSE 350 companies is still low.

Further insight into the disclosures is provided in Table 3. A review of the disclosures indicates that overall, more qualitative than quantitative disclosures were made. For instance, in 2008, the firms disclosed about 31% of all available qualitative disclosures against just 17% of the available quantitative disclosures (see Table 3, Panel B). However, over the whole period studied, firms progressively increased their level of quantitative disclosures, reporting about 30% of the items in 2011, compared with 17% in 2008. On the qualitative disclosures, most frequently reported were the actions/measures taken to reduce/mitigate climate change impact, with almost 96% of the firms reporting these in 2011 (see Table 3, Panel A, Item 9). This could suggest desire on the part of the companies to shift the focus of their target audience from actual to intended impact on climate change. The least disclosed qualitative information in all the years was the disclosure of supplier and the name of the green tariff purchased, with 4% of the firms disclosing this information in 2008 and 6% by 2011 (see Table 3, Panel A, Item 25).

The number of firms disclosing their reporting framework guidelines has also increased from 39% in 2008 to 63% in 2011 (see Table 3, Panel A, Item 12). Over the same period, there has been a marginal increase in the number of firms obtaining assurance services on their GHG emissions reporting – from 16% in 2008, to 27% in 2011 (see Table 3, Panel A, Item 13). This could imply unwillingness on the part of the companies to dedicate resources to improving the quality of their GHG reporting. As argued by Hrasky (2012), companies have now resorted to mere symbolism in terms of carbon disclosure, hence the need

**Table 2**
GHG disclosure trend 2008–2011.

| Year | Mean | Std dev. | Min. | Max. | Skewness | Kurtosis |
|---|---|---|---|---|---|---|
| 2008 | 0.25 | 0.20 | 0 | 0.78 | 0.94 | 2.99 |
| 2009 | 0.31 | 0.22 | 0 | 0.85 | 0.74 | 2.44 |
| 2010 | 0.35 | 0.21 | 0.02 | 0.88 | 0.60 | 2.24 |
| 2011 | 0.39 | 0.23 | 0 | 0.88 | 0.40 | 2.09 |
| 2008–2011 | 0.32 | 0.22 | 0 | 0.88 | 0.66 | 2.37 |

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**Table 3**
Panel A: Consolidated disclosure scores for all industries. Panel B: Summary GHG disclosure scores.

Panel A

| Disclosure item | | 2008 | | 2009 | | 2010 | | 2011 | |
|---|---|---|---|---|---|---|---|---|---|
| | | Absolute freq. | Relative (%) | Absolute freq. | Relative (%) | Absolute freq. | Relative (%) | Absolute freq. | Relative (%) |
| *Qualitative disclosures* | | | | | | | | | |
| 1 | Institutional background | 206 | 95% | 213 | 99% | 213 | 99% | 213 | 99% |
| 2 | Period covered by the report | 203 | 94% | 212 | 98% | 212 | 98% | 212 | 98% |
| 3 | Statement on company position on climate change and related responsibilities | 190 | 88% | 200 | 93% | 203 | 94% | 202 | 94% |
| 4 | Corporate governance on climate change | 165 | 76% | 182 | 84% | 187 | 87% | 191 | 88% |
| 5 | Climate change opportunities and company strategies | 110 | 51% | 126 | 58% | 138 | 64% | 137 | 63% |
| 6 | Climate change impact on business operations, including supply chains | 80 | 37% | 95 | 44% | 105 | 49% | 111 | 51% |
| 7 | Identification of regulatory risks as a result of climate change | 40 | 19% | 53 | 25% | 61 | 28% | 67 | 31% |
| 8 | Identification of all other risks as a result of climate change | 54 | 25% | 64 | 30% | 78 | 36% | 92 | 43% |
| 9 | Actions/measures taken to reduce/mitigate climate change impact | 183 | 85% | 203 | 94% | 206 | 95% | 207 | 96% |
| 10 | Adaptation strategies to climate change effects | 77 | 36% | 96 | 44% | 101 | 47% | 103 | 48% |
| 11 | Regulated schemes to which a firm belongs | 31 | 14% | 58 | 27% | 73 | 34% | 79 | 37% |
| 12 | Reporting guidelines used in GHG reporting | 84 | 39% | 112 | 52% | 132 | 61% | 135 | 63% |
| 13 | An assurance statement on disclosed information | 35 | 16% | 45 | 21% | 53 | 25% | 58 | 27% |
| 14 | Contact or responsible person for GHG reporting | 113 | 52% | 138 | 64% | 155 | 72% | 163 | 75% |
| 15 | Organisation boundary and consolidation approach | 65 | 30% | 77 | 36% | 89 | 41% | 98 | 45% |
| 16 | Base year | 77 | 36% | 92 | 43% | 111 | 51% | 126 | 58% |
| 17 | Explanation for a change in base year | 40 | 19% | 51 | 24% | 59 | 27% | 69 | 32% |
| 18 | GHGs covered, including those not required by Kyoto protocol | 44 | 20% | 58 | 27% | 62 | 29% | 68 | 31% |
| 19 | Sources and sinks used/excluded | 51 | 24% | 64 | 30% | 74 | 34% | 88 | 41% |
| 20 | Conversion factors used/methodology used to measure or calculate emissions | 40 | 19% | 58 | 27% | 70 | 32% | 83 | 38% |
| 21 | Explanation for any changes to methodology or conversion factors previously used | 31 | 14% | 43 | 20% | 59 | 27% | 64 | 30% |
| 22 | A list of facilities included in the inventory for GHG emissions | 16 | 7% | 23 | 11% | 29 | 13% | 37 | 17% |
| 23 | Information on the quality of the inventory, e.g. causes and magnitude of uncertainties in estimates | 2 | 1% | 5 | 2% | 9 | 4% | 13 | 6% |
| 24 | Information on any GHG sequestration | 18 | 8% | 29 | 13% | 37 | 17% | 37 | 17% |
| 25 | Disclosure of the supplier and the name of the purchased green tariff | 8 | 4% | 8 | 4% | 11 | 5% | 13 | 6% |
| 26 | Explanations for changes in performance of total GHG emissions in $CO_2$ metric tonnes | 100 | 46% | 126 | 58% | 141 | 65% | 154 | 71% |
| 27 | Explanation of any country excluded, if global total is reported | 75 | 35% | 93 | 43% | 106 | 49% | 111 | 51% |
| 28 | Explanations for changes in performance of scope 1 emissions | 35 | 16% | 49 | 23% | 60 | 28% | 69 | 32% |
| 29 | Details of any specific exclusion of emissions from scope 1 | 22 | 10% | 34 | 16% | 50 | 23% | 55 | 25% |
| 30 | Explanation for the reason of any exclusion from scope 1 | 18 | 8% | 29 | 13% | 40 | 19% | 45 | 21% |
| 31 | Explanations for changes in performance of scope 2 emissions | 34 | 16% | 48 | 22% | 58 | 27% | 65 | 30% |
| 32 | Details of any specific exclusion of emissions from scope 2 | 22 | 10% | 34 | 16% | 49 | 23% | 53 | 25% |
| 33 | Explanation for the reason of any exclusion from scope 2 | 18 | 8% | 29 | 13% | 39 | 18% | 44 | 20% |

(*continued on next page*)

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**Table 3** (*continued*)

Panel A

| Disclosure item | | 2008 | | 2009 | | 2010 | | 2011 | |
|---|---|---|---|---|---|---|---|---|---|
| | | Absolute freq. | Relative (%) | Absolute freq. | Relative (%) | Absolute freq. | Relative (%) | Absolute freq. | Relative (%) |
| 34 | Explanations for changes in performance of scope 3 emissions | 23 | 11% | 35 | 16% | 48 | 22% | 59 | 27% |
| *Quantitative disclosures* | | | | | | | | | |
| 35 | Total GHG emissions in $CO_2$ metric tonnes | 117 | 54% | 138 | 64% | 154 | 71% | 170 | 79% |
| 36 | Comparative data of total GHG emissions in $CO_2$ metric tonnes | 103 | 48% | 125 | 58% | 142 | 66% | 159 | 74% |
| 37 | Future estimates of total GHG emissions in $CO_2$ metric tonnes | 10 | 5% | 13 | 6% | 13 | 6% | 15 | 7% |
| 38 | GHG emission by business unit/type/country | 75 | 35% | 90 | 42% | 108 | 50% | 123 | 57% |
| 39 | GHG removals quantified in tonnes of $CO_2e$ | 23 | 11% | 29 | 13% | 36 | 17% | 43 | 20% |
| 40 | Scope 1 emissions | 28 | 13% | 41 | 19% | 54 | 25% | 63 | 29% |
| 41 | Comparative data on scope 1 emissions | 20 | 9% | 32 | 15% | 47 | 22% | 56 | 26% |
| 42 | Future estimates of scope 1 emissions | 1 | 0% | 2 | 1% | 3 | 1% | 3 | 1% |
| 43 | Scope 2 emissions | 28 | 13% | 40 | 19% | 53 | 25% | 62 | 29% |
| 44 | Comparative data on scope 2 emissions | 20 | 9% | 32 | 15% | 46 | 21% | 54 | 25% |
| 45 | Future estimates of scope 2 emissions | 1 | 0% | 2 | 1% | 3 | 1% | 5 | 2% |
| 46 | Scope 3 emissions | 18 | 8% | 29 | 13% | 39 | 18% | 50 | 23% |
| 47 | Comparative data on scope 3 emissions | 14 | 6% | 24 | 11% | 36 | 17% | 45 | 21% |
| 48 | Future estimates of scope 3 emissions | 1 | 0% | 2 | 1% | 3 | 1% | 3 | 1% |
| 49 | Emission of direct $CO_2$ reported separately from scopes | 60 | 28% | 68 | 31% | 81 | 38% | 95 | 44% |
| 50 | Emission not covered by Kyoto and reported separately from scopes | 57 | 26% | 67 | 31% | 83 | 38% | 95 | 44% |
| 51 | Emission attributable to own generation of electricity/heat/steam sold or transferred to another organ. | 81 | 38% | 93 | 43% | 103 | 48% | 116 | 54% |
| 52 | Emission attributable to own generation of electricity/heat/steam purchased for resale to end users | 36 | 17% | 48 | 22% | 54 | 25% | 63 | 29% |
| 53 | For purchased green tariff, state the reduction in tonnes of $CO_2e$ per year | 7 | 3% | 13 | 6% | 16 | 7% | 17 | 8% |
| 54 | Additional carbon saving associated with the tariff as a percentage | 2 | 1% | 6 | 3% | 6 | 3% | 5 | 2% |
| 55 | Quantitative data estimates of the regulatory risks as a result of climate change | 1 | 0% | 1 | 0% | 1 | 0% | 1 | 0% |
| 56 | Quantitative data estimates of all other risks as a result of climate change | 1 | 0% | 1 | 0% | 1 | 0% | 2 | 1% |
| 57 | GHG emission performance measurement against internal and external benchmarks, including ratios | 57 | 26% | 79 | 37% | 89 | 41% | 105 | 49% |
| 58 | GHG emission targets set and achieved | 82 | 38% | 108 | 50% | 122 | 56% | 139 | 64% |
| 59 | GHG emission offsets information | 26 | 12% | 33 | 15% | 39 | 18% | 48 | 22% |
| 60 | Comparative information on targets set and achieved | 75 | 35% | 99 | 46% | 115 | 53% | 133 | 62% |

Panel B

| Type of disclosure | 2008 | | | 2009 | | | 2010 | | | 2011 | | | 2008–2011 | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | All firms score | Max. poss. score[a] | % of score | All firms score | Max. poss. score[a] | % of score | All firms score | Max. poss. score[a] | % of score | All firms score | Max. poss. score[a] | % of score | All firms score | Max. poss. score[a] | % of score |
| Qualitative disclosures | 2310 | 7344 | 31% | 2782 | 7344 | 38% | 3118 | 7344 | 42% | 3321 | 7344 | 45% | 11,531 | 29,376 | 39% |
| Quantitative disclosures | 944 | 5616 | 17% | 1215 | 5616 | 22% | 1447 | 5616 | 26% | 1670 | 5616 | 30% | 5276 | 22,464 | 23% |
| Total GHG disclosure score | 3254 | 12,960 | 25% | 3997 | 12,960 | 31% | 4565 | 12,960 | 35% | 4991 | 12,960 | 39% | 16,807 | 51,840 | 32% |

[a] Maximum possible score is derived by multiplying total number of firms and total disclosure items available per category.

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**Table 4**
Pooled descriptive statistics for independent variables.

| Variables | Mean | Std dev. | Min | Max | Skewness | Kurtosis |
|---|---|---|---|---|---|---|
| DEFRA | 0.5 | 0.50 | 0.00 | 1.00 | 0.00 | 1.00 |
| Board size (number) | 9.19 | 2.62 | 4 | 31 | 1.43 | 8.79 |
| NEDs (ratio) | 0.65 | 0.11 | 0.29 | 0.93 | −0.26 | 2.75 |
| Director ownership (%) | 5.46 | 13.25 | 0 | 85.37 | 2.99 | 11.59 |
| Ownership concent. (%) | 40.23 | 17.80 | 3.55 | 91.47 | 0.17 | 2.47 |
| Size (£million) | 9594.02 | 31638.90 | 40.00 | 345257.00 | 7.06 | 60.74 |
| Gearing (ratio) | 1.52 | 12.52 | 0.02 | 246.24 | 15.45 | 255.25 |
| Profitability (%) | 8.97 | 11.57 | −84.6 | 120.39 | 1.11 | 30.38 |
| Liquidity (ratio) | 1.62 | 1.70 | 0.19 | 27.28 | 7.46 | 90.27 |
| Firm age (years) | 23.62 | 20.62 | 0 | 80 | 0.86 | 2.50 |
| Financial slack (ratio) | 0.71 | 6.69 | 0 | 104.22 | 11.96 | 154.57 |
| Capital expenditure (ratio) | 0.21 | 0.98 | 0 | 17.65 | 11.16 | 155.19 |

for government intervention to improve the quality of disclosures. Voluntary disclosure is also considered less reliable, as managers tend to focus on areas that suit their needs rather than on genuine desire for accountability (Neu, Warsame, & Pedwell, 1998); hence, there is consensus that reliability can be achieved only through regulation (Deegan, 2004).

The most frequently reported quantitative item in all the years under review was the total GHG emissions in $CO_2$ metric tonnes, reported by 79% of the firms in 2011 (see Table 3, Panel A, Item 35). However, over the same period, evidence indicates low levels of GHG quantitative disclosure per scope. For example, only 13% of the firms reported their GHG emissions for scope 1 in 2008; by 2011, the figure had risen to only 29% (see Table 3, Panel A, Item 40). A similar finding was recorded by Dragomir (2012), who noted that a sample of companies including BP, Total, Shell, BG Group, and Eni had largely disclosed GHG emissions in total rather than per scope.

There was a lack of quantitative information relating to future estimates of emissions and quantifiable estimates of regulatory risks arising from climate change, with just 1% of the firms disclosing this for all the years of 2008–2011 (see Table 3, Panel A, Items 42, 45, & 48). This reflects the findings of Haque and Deegan (2010), who noted that Australian companies' GHG emission disclosures had provided only limited insights into climate change risks and opportunities. This could, arguably, imply failure on the part of the firms to fully integrate GHG reporting into the other parts of the business. Kolk et al. (2008) reported that, in general, their sampled firms' GHG disclosures demonstrated no link among strategy, performance, and GHG emissions – which meant there was a lack of GHG integration into mainstream business strategies. Stanny (2011) interpreted the lack of effort by firms to improve the quality of disclosures as confirmation of legitimacy theory, arguing that – in this respect – firms disclose the minimum possible to meet stakeholders' needs. Alternatively, a lack of quantitative disclosures may imply that firms use disclosure merely as a means of carbon performance story-telling, with such stories not corresponding to reality on the ground (Bowen & Wittneben, 2011). Thus, increased qualitative disclosures might sometimes lead to less transparency and accountability, as real actions/impacts (which can be identified through quantitative disclosures) are hidden in long-winded and often well-crafted stories.

### 4.2. Descriptive statistics – independent variables

The descriptive statistics for the continuous independent variables in Table 4 indicate that the mean board size was about nine directors, with a minimum of four and maximum of 31. The companies had low levels of director ownership (as indicated

**Table 5**
Correlation among dependent and independent variables.

| | 1 | 2 | 3 | 4 | 5 | 6 | 7 | 8 | 9 | 10 | 11 | 12 | 13 | 14 |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| 1. Disclosure | 1.00 | | | | | | | | | | | | | |
| 2. DEFRA | 0.20*** | 1.00 | | | | | | | | | | | | |
| 3. Board size | 0.39*** | −0.03 | 1.00 | | | | | | | | | | | |
| 4. Non-executive direc. | 0.16*** | 0.08** | 0.11** | 1.00 | | | | | | | | | | |
| 5. Director ownership. | −0.21*** | −0.03 | −0.11** | −0.11*** | 1.00 | | | | | | | | | |
| 6. Ownership concent. | −0.28*** | 0.02 | −0.24*** | 0.02 | 0.21*** | 1.00 | | | | | | | | |
| 7. Firm size | 0.54*** | 0.05 | 0.62*** | 0.34*** | −0.18*** | −0.38*** | 1.00 | | | | | | | |
| 8. Gearing | −0.03 | −0.00 | −0.04 | −0.02 | −0.03 | −0.06* | 0.02 | 1.00 | | | | | | |
| 9. Profitability | −0.02 | 0.12*** | −0.04 | 0.07** | 0.03 | 0.04 | −0.14*** | −0.02 | 1.00 | | | | | |
| 10. Liquidity | −0.11*** | 0.02 | −0.14*** | 0.05 | 0.11** | 0.18*** | −0.13*** | −0.02 | −0.02 | 1.00 | | | | |
| 11. Firm age | −0.06* | 0.05 | 0.05 | −0.03 | −0.18*** | −0.28*** | 0.03 | 0.13*** | −0.02 | −0.04 | 1.00 | | | |
| 12. Financial slack | 0.10*** | 0.00 | 0.06* | 0.14*** | 0.00 | 0.07** | 0.03 | 0.01 | −0.03 | 0.02 | −0.01 | 1.00 | | |
| 13. Capital expenditure | 0.06* | 0.04 | 0.02 | −0.03 | −0.08** | −0.06* | 0.01 | 0.02 | 0.12*** | −0.20*** | 0.14*** | 0.02 | 1.00 | |
| 14. Industry | −0.04 | 0 | 0.06 | 0.05 | 0.05 | 0.03 | 0.12*** | 0.09*** | 0.03 | 0.22*** | −0.08** | 0.04 | 0.21*** | 1.00 |

* ** *** significant at 10%, 5% and 1% respectively.

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by a mean of 5.46%) and moderate levels of ownership concentration (as suggested by the mean of 40.23% over the four-year period). The size of firms (measured by total assets) had a wider range and great variability between years. For example, total assets ranged from £40 million to £345,257 million, with a mean of £9594.02 million and standard deviation of £31,638.9 million. The majority of the firms sampled were highly geared (with a mean of 1.52).

There was great variability with regard to profitability. For example, companies in the sample had a return on assets ranging from −84.6% to 120.39%, with a standard deviation of 11.57. It is also noticeable that the company size, gearing, profitability, financial slack, liquidity, and capital expenditure variables have high levels of kurtosis. However, Tabachnick and Fidell (2007) argued that in large samples, the impact of skewdness and kurtosis values from normality is suppressed. In this case, therefore, the effect of the non-normal distribution in the independent variables is unlikely to affect the final outcome.

### 4.3. Correlation of dependent and independent variables

In Table 5, we present correlations among the dependent and independent variables. The results show that there are no high correlations among all the independent variables except for between board size and company size, which had a significant positive correlation of 0.62. According to Field (2009), a correlation of independent variables of above 0.8 is a cause for concern; hence, the correlation between board size and company size is considered to have less impact on the overall result. However, according to Myers (1990), a certain degree of multicollinearity can still exist, even when none of the correlation coefficients is very large. Therefore, we also examine the variance inflation factors in our models to test further for multicollinearity.

Furthermore, we carried out both the Breusch–Pagan/Cook–Weisberg test for heteroscedasticity and White's test for homoscedasticity; if heteroscedasticity were present but not controlled, the standard errors and any associated tests could be false. In both cases, the test statistic was highly significant, indicating the presence of heteroscedasticity. According to Berry and Feldman (1985), heteroscedasticity can be controlled through various means, including variable transformation and the use of robust standard errors. In this paper, both options have been used; some variables notably firm size were transformed logarithmically, and again the option of robust was used in Stata 12 (the data analysis software we employed).

### 4.4. Multivariate results and discussion

The results are presented using two models in Table 6. What differentiates Model 1 from Model 2 is the characteristic of our time variable. In Model 1, a dummy variable ('DEFRA') has been used to capture the time effect, while in Model 2 there are four dummy variables representing time effect. Model 1 results indicate that 'DEFRA', corporate governance variables (board size, director ownership, and ownership concentration) and company-specific control variables (size, gearing, financial slack, and industry) all have a significant effect on GHG disclosure scores. All the coefficients were statistically significant at 0.01, with the exception of board size and ownership concentration, which had significance of 0.05. The corporate governance variable (NEDs) and company-specific control variables (profitability, liquidity, firm age, and capital expenditure) have no significant relationship with GHG disclosure. The model explains 32% of the variation in the extent of GHG disclosure.

The results of Model 2, which explain 33% of the variation in GHG disclosure, confirm the significance of the time dummy variables (representing the effect of DEFRA's 2009 guidance). Analysis of the time effects showed that the change in GHG

**Table 6**
Multivariate results.

| GHG disclosure (DV) | Model 1 | | Model 2 | |
|---|---|---|---|---|
| | Coefficient[a] | Robust std. err. | Coefficient[a] | Robust std. err. |
| DEFRA | 0.08*** | 0.01 | – | – |
| Board size | 0.07** | 0.04 | 0.08** | 0.04 |
| NEDs | −0.08 | 0.07 | −0.08 | 0.07 |
| Director ownership | −0.00*** | 0.00 | −0.00*** | 0.00 |
| Ownership concentration | −0.00** | 0.00 | −0.00*** | 0.00 |
| Size | 0.07*** | 0.01 | 0.07*** | 0.01 |
| Gearing | −0.00*** | 0.00 | −0.00*** | 0.00 |
| Profitability | 0.00 | 0.00 | 0.00 | 0.00 |
| Liquidity | 0.00 | 0.01 | 0.00 | 0.01 |
| Firm age | −0.01 | 0.01 | −0.01 | 0.01 |
| Financial slack | 0.00*** | 0.00 | 0.00*** | 0.00 |
| Capital expenditure | 0.00 | 0.01 | 0.00 | 0.01 |
| Industry | −0.04*** | 0.01 | −0.04*** | 0.01 |
| Year 2009 | – | – | 0.06*** | 0.02 |
| Year 2010 | – | – | 0.09*** | 0.02 |
| Year 2011 | – | – | 0.12*** | 0.02 |
| *R-Squared* | 0.34 | | 0.34 | |
| *Adj. R-Squared* | 0.32 | | 0.33 | |

[a] Most coefficients are 0.00 due to rounding off to two decimal places; ***$p < 0.01$, **$p < 0.05$.

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disclosure was most pronounced between 2009 and 2010, as indicated by the change in *t*-ratio. The results also indicate that corporate governance variables (board size, director ownership, and ownership concentration) and company-specific control variables (size, gearing, financial slack, and industry) are significant, as identified in Model 1. As a result, H1 is confirmed, as are H2, H4, and H5. The results in Model 2, which show the non-significance of one corporate governance variable (NEDs), mean that H3 is not confirmed.

Our finding on the effect of the 2009 DEFRA guidance is consistent with prior studies, for example Freedman and Jaggi (2005), whose investigation found that firms operating in Kyoto-ratifying countries made more disclosures than their counterparts elsewhere. Similarly, Sidaway and De Lange (2011) found that the introduction of the National Greenhouse and Energy Reporting Act in Australia had positively influenced firms not targeted by this, encouraging them to voluntarily disclose climate change information. Besides, other research evidence indicates that companies tend to respond positively to government guidance or proposals in anticipation of regulation (Inchausti, 1997; Llena et al., 2007).

From the evidence, it could be argued that firms appear to have embraced the 2009 DEFRA guidance as pseudo-regulatory (i.e. indicating the direction of future policy and legislation), and so as useful to comply with. It could also suggest that this guidance provided reasonable justification for managers to invest in systems to collect and report GHG emissions. In fact, the Confederation of British Industry (CBI), an influential industry umbrella body in the UK, hailed the introduction of the 2009 DEFRA guidance as a step towards the mandatory reporting for which it had been calling, as a way of achieving consistency and comparability of results (CBI, 2011). Evidence documented by De Villiers and Van Staden (2011b) also suggests that investors have been very supportive of the move towards government regulation/guidance on GHG reporting.

The results relating to the effect of corporate governance are consistent with our hypotheses, apart from that relating to NEDs. Our finding that board size is positive and significant suggests that this is important to GHG disclosure, and is consistent with prior studies (Cormier et al., 2011; Peters & Romi, 2012). Dalton et al. (1999) argued that larger boards tend to have diverse skills and experience, allowing greater oversight (in this case on GHGs). The results, which indicate that both ownership concentration and director ownership have a significant negative association with GHG voluntary disclosure, imply that directors and large shareholders have channels other than those investigated here to gather a firm's information on GHG emissions. Other studies (e.g. Barker, 1998) found that most fund managers (who formed the core of institutional investors and ownership concentration in the UK) considered meetings with senior managers to be their most important source of information. In the case of GHG emissions, it could be argued that other avenues (such as CDP disclosure) are used or encouraged by institutional investors; hence, they may not find encouraging managers to disclose GHG information in other media to be worthwhile.

On the other hand, the misfit of the variable 'NEDs' in the model suggests that the proportion of NEDs on the board has no influence on GHG disclosure. As this variable often represents the level of independence relating to board decisions, it suggests that whether the board is free from material influence by either owners or managers is of no consequence to GHG disclosure. Seen in the light of stakeholder-agency theory, this is a contradiction because agency theory encourages high numbers of NEDs on the board as a mechanism to keep managerial opportunism in check and to reduce agency costs. However, the result is consistent with prior studies (Ho & Wong, 2001). This could be explained by Mangena and Tauringana's (2007) argument that NEDs might be preoccupied with other matters and so fail to pay proper attention to the equally important matter of disclosure, or simply delegate it to a particular sub-committee. Others argue that NEDs may not *per se* be independent in practice, due to other influences that may compromise their professional judgement (Buniamin, Alrazi, Johari, & Rahman, 2008). One plausible explanation could be that these board structures are yet to reposition themselves to meet the challenges of climate change. Kock et al. (2012) alluded to the fact that board characteristics such as those covered in our study, being primarily designed for different sets of objectives, may not be useful in achieving environmental aims. Mallin, Michelon, and Raggi (2013) argued that there is no straightforward path between corporate governance and social/environmental disclosure, and so called for innovative techniques to prove the link. Arguably, the period covered by the study coincided with the financial crisis; hence, firms and their boards were preoccupied with repositioning themselves to respond to the inadequacies exposed during the crisis, meaning that issues relating to GHGs might have had less prominence.

The results of the underlying company-specific control variables also indicate that company size is positively associated with disclosure of more GHG information. This is consistent with prior studies on GHG disclosure, such as those by Freedman and Jaggi (2005), Prado-Lorenzo et al. (2009), Rankin et al. (2011), Berthelot and Robert (2012), and Adams, Hill, and Roberts (1998). The negative coefficient in respect of gearing means that highly geared companies are likely to disclose less information on GHG emissions. While the result contradicts the findings of prior studies on GHG disclosure (see Freedman & Jaggi, 2005; Prado-Lorenzo et al. 2009; Rankin et al., 2011), it is consistent with those of Brammer and Pavelin (2008). There was a positive significant relationship between financial slack and GHG voluntary disclosures. Our finding on the industry variable is interesting but ambiguous when compared to prior studies. The literature on climate change and GHG disclosure (Freedman & Jaggi, 2005; Prado-Lorenzo et al., 2009; Rankin et al., 2011) – though not in complete agreement on which sectors are more prominent when it comes to disclosure – largely agrees that some industries deemed heavy polluters disclose more information. Our results contradict this, instead finding evidence that those industries deemed less environmentally risky disclose more information than their counterparts. We argue that this may reflect not only the sample's characteristics and the instrument used to measure the extent of disclosure but also the nature of GHG emissions. Firms in heavily polluting industries may feel that greater disclosure exposes them more, and so may be unforthcoming when it comes to transparency and accountability for their emissions (Prado-Lorenzo & Garcia-Sanchez, 2010; Wegener, Elayan, Felton, & Li,

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2013). On the other hand, less environmentally risky industries may disclose more as a way of pre-empting potential regulation that might be costly to comply with.

### 4.5. Robustness check

A study such as this could be subject to a number of statistical limitations, including endogeneity, which occurs when a model omits some variables of interest and so fails to provide a full picture. One solution is to include all known variables and find suitable instruments to measure (or proxies for) other factors. We did incorporate some known governance variables in the regression model that were not in our model but have been extensively used in prior disclosure studies. Our rationale was that research into governance and environmental studies is extensive, and many aspects of governance have been tested before that, if left out, could have meant our understanding was incomplete – and hence could have compounded the problem of endogeneity (Wang & Hussainey, 2013). The variables tested were size of the audit committee, presence of an environmental committee, gender diversity (using proportion of female board members), directors' age, and frequency of board meetings; all were non-significant, and the explanatory power of our model did not surpass the 33% reported in our model (with results available upon request). We also reviewed the possibility of including CEO duality in the model. However, based on our sample, this was deemed inadequate to generate meaningful statistical results, since there were only five firms with CEO duality.

In addition, based on our literature review, we noted that the industry variable is categorised differently (e.g. Prado-Lorenzo et al., 2009, had 11 categories; Rankin et al., 2011, had four; and Freedman & Jaggi, 2005, had five). We therefore reclassified our industry variable based on the Industry Classification Benchmark, and this resulted in nine industry categories (having excluded finance). We then ran the two models again, using the reclassified industry variable, but the results did not materially differ from our models (in that neither the direction nor significance of the explanatory variables changed). Results are not included here but are available on request. After estimating models with all nine industry variables and with only one industry variable, a log-likelihood ratio was run to determine the appropriate model. Our chi-square indicated that clustering the industry variable into one dummy variable resulted in a statistically significant model. The log-likelihood ratio had LR $chi^2$ (8) of 28.70, with Prob > $chi^2$ of 0.00. Based on these results, the models with results reported in Table 6 was deemed more appropriate.

## 5. Summary and conclusion

This paper investigated the effect of the 2009 DEFRA guidance on the extent of GHG disclosure and how corporate governance characteristics moderate this. Based on the statistical evidence presented here, the guidance did indeed impact on GHG voluntary disclosure, demonstrating how government intervention can help bring in line firms' behaviour on voluntary disclosure. There is also evidence that the level of disclosure is moderated by corporate governance variables (board size, directors' share ownership, and ownership concentration) and company-specific characteristics (size, leverage, financial slack, and industry). Our results are also consistent with prior studies on the effect of government regulation or guidance (Canace et al., 2010; Heflin et al., 2012; Kalelkar & Nwaeze, 2011; Llena et al., 2007; Rankin et al., 2011; Sidaway & De Lange, 2011); in addition, although Mangena and Tauringana (2007) did not investigate the effect of DEFRA's guidance, they found disclosure evidence consistent with response to policy or regulation in general. Our results also fit with previous findings on board size (Cormier et al., 2011; Peters & Romi, 2012), NEDs (Brammer and Pavelin (2008)), ownership concentration (Brammer & Pavelin, 2008; Matolcsy, Shan, & Seethamraju, 2012), and managerial ownership (Gelb, 2000).

The fact that a combination of DEFRA's guidance and corporate governance/company-specific control variables have been found to influence GHG voluntary disclosure suggests that neither pseudo-regulatory guidelines (such as the guidance) nor market forces (represented by the various corporate governance and company-specific characteristics) can satisfactorily encourage a firm to disclose information to meet stakeholder needs. In other words, our results justify some form of intervention if the extent of voluntary disclosure is to be improved. This is also supported by the findings of De Villiers and Van Staden (2011b) who – after surveying shareholders from Australia, the UK, and the USA – concluded that, in all countries, shareholders expressed a preference for mandatory environmental disclosure in annual reports. In fact, 50% of UK shareholders supported a move towards prescribed regulation. Calls for regulation are bolstered by the fact that many consider voluntary disclosure of information – such as that on GHG emissions – to be less reliable as managers tend to focus on areas that suit their needs (Neu et al., 1998), and hence reliability can be achieved through regulation (Deegan, 2004). According to Boston and Lempp (2011), regulation in this respect will not only reduce apathy in disclosure and reliability but will also encourage firms to take real action on reducing emissions. This is probably why the UK government has made GHG disclosure mandatory from 2013 for all London Stock Exchange-listed companies. It should, however, be noted that in the field of climate change – where a number of issues (such as its science and impact) are still not universally accepted, and firms are only slowly buying into the idea of climate change being of strategic importance (Griffin, Lont, & Sun, 2011; Griffin & Sun, 2012; Yen & Yen, 2012) – the stepwise introduction of regulation was and remains an ideal way forward. Thus, the enactment of the CCA (2008), subsequent consultation and the issuance of DEFRA's (2009) guidance, and then the timing of the release of mandatory requirements for GHG disclosure in September 2013 meant that companies have been given ample time to gain experience of disclosure through complying with guidelines before moving to a compulsory regime. Considering that various

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controversial policy and scientific issues surround climate change, we argue that this could be an appropriate model for future regulation in this area.

The study has a number of limitations. First, the sample was extracted from FTSE 350 companies after excluding financial companies. Future research might extend the sample to include these companies and some medium/small companies, since DEFRA's (2009) guidance can be used by any company regardless of the nature of its operations or its size. Second, our analysis is restricted to disclosures made in annual reports and in sustainability reports, and no attempt has been made to compare these with disclosures made through other avenues, such as the CDP. Therefore, future studies might compare these avenues in order to learn useful lessons.

Despite these limitations, the study makes the following contributions to the disclosure literature. First, the study contributes to the ongoing debate on the efficacy of voluntary over mandatory disclosure, in particular highlighting whether voluntary disclosure can be relied upon to provide adequate information to meet various stakeholder needs. Hess (2008) argued that voluntary disclosure often indicates the extent to which mandatory guidelines may enforce compliance. This is especially important given that the UK government has now made GHG reporting mandatory. Second, the study contributes to the understanding of GHG voluntary disclosure practices by UK firms in the context of the requirements of a number of GHG disclosure guidance. This contrasts with GHG disclosure indexes used by most extant research (e.g. Peters & Romi, 2012; Stanny, 2011), which tend to be based on only one set of GHG disclosure guidance. Third, the study provides evidence of the effect of corporate governance and company-specific control variables on GHG disclosure in the UK, where there is limited empirical evidence. Finally, our study's inclusion of companies from a diverse range of industries sets it apart from prior GHG disclosure studies, which have tended to predominantly focus on the so-called 'environmentally sensitive' industries.

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