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Carbon risk management, carbon disclosure and stock market effects: An international perspective.

A dissertation submitted by

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ABSTRACT

This research investigates interrelations between carbon risk management, carbon disclosure, and two measures of stock market effects: the ex-ante cost of equity capital and market value. It is conducted based on a sample comprising the 500 largest global companies (G500) in 2009. Carbon risk management in this research is defined as the firm's ability to estimate its historical and expected carbon intensity, identify potential carbon and climate change risks and associated opportunities, actions undertaken or planning to undertake to minimise risks and maximise opportunities, and the firm's efficiency and effectiveness in managing these issues. Carbon disclosure is defined as set of quantitative and qualitative information that relates to a firm's past and forecasted carbon emissions levels; its exposure to and financial implications of climate change associated risk and opportunities; and its past and future actions to manage these risks and opportunities.

Three major contributions to the literature are made by this research. First, this study extends the literature on the relationship between environmental performance and disclosure by examining a specific and topical type of environmental performance and disclosure: carbon risk management and carbon disclosure. The results provide new evidence and support the prediction of economics-based disclosure theories (signalling and voluntary disclosure theories) that environmental disclosure is positively associated with environmental performance. Firms with superior carbon risk management tend to provide high quality and detailed disclosure about their carbon and climate change performance. When carbon risk management is controlled, these results reject the conjecture of socio-political theories (legitimacy and stakeholder theories) that inferior carbon risk performers provide more positive

carbon disclosures. These results are further supported by intra-country and industry analyses as well as disaggregation of carbon risk management and disclosure into its components (sub-scores).

The disaggregated scores analyses reveals the role of particular carbon risk management practices in enhancing disclosure quality about them. Firm's historical carbon risk management as measured by its carbon emissions intensity is not associated with disclosure quality about the actual emissions and accounting standards to calculate them. In contrast, all other current and future carbon risk management strategies are positively associated with the disclosure quality about these strategies. This suggests that firms' management are more likely to disclose high quality and credible information about their commitment to tackle climate change risks than their historical emissions since it reflects their historical emissions performance. These results, therefore, highlight the importance of partitioning carbon risk management and disclosure measurements to their components rather than relying on aggregated indices.

Second, it develops comprehensive definitions and measurements for carbon risk management and disclosure. These new definitions and measurements tackle some shortcomings prevalent in prior research; thus, enhancing the rigour of results. Third, this research contributes to the debate about the economic consequences of environmental performance-disclosure activities by investigating the stock market effects of carbon risk management and carbon disclosure. This study fails to find a significant association between carbon risk management and disclosure and stock market indicators as expressed by the ex-ante cost of equity capital and market value.

These results suggest that better carbon risk management and disclosure practices do not lower the ex-ante cost of equity capital or increase a firm's market value. These results could be viewed in two ways. First, investors may not know how to interpret carbon risk management related information; thus they do not consider this information to be useful or they do not know how to value it. Second, investors are not interested in carbon risk management and disclosure activities or do not believe that engaging with such activities could lead to change in a firm's reputation and competitive advantage or a reduction in risk. Hence, they do not make investment decisions on this basis. These results are robust to several additional analyses. Intra-industry and country analyses show similar results. Additionally, other tests are performed to check whether investors are interested in particular carbon risk management activities or disclosure categories such as historical emissions data or future carbon risk management strategies and activities. Once again, no association between stock market indicators and carbon risk management and disclosure categories is observed.

CERTIFICATION OF DISSERTATION

I certify that the ideas, analyses, results and conclusions contained in this dissertation are entirely my own effort, except where otherwise acknowledged. I also certify that the work is original and has not been previously submitted for any other award, except where otherwise acknowledged.

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Signature of Candidate Date

ENDORSEMENT

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Signature of Supervisor Date

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Signature of Supervisor Date

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CANDIDATE'S PUBLICATIONS

Journal papers with other authors (note, this work is indirectly related to my PhD research):

Cotter, J., Lokman, N. And Najah, M., 2011 "Voluntary disclosure research: Which theory is relevant?" *Journal of Theoretical Accounting Research*, vol. 6, no. 2, pp. 77-95.

Cotter, J., Najah, M. and Wang, S., 2011 "Standardized reporting of climate change information in Australia", *Sustainability Accounting, Management and Policy Journal*, vol. 2, no. 2, pp. 294-321

Cotter, J. and Najah, M., 2012 "Institutional investor influence on global climate change disclosure practices" forthcoming in *Australian Journal of Management*, Special Issue on Sustainable Finance and Investing.

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CHAPTER 1 INTRODUCTION

1.1 Background

Climate change has become potentially one of the most important problems affecting the future of life on this planet. This threat can be seen from different perspectives including the endangerment of flora and fauna, impacts on human health and social upheaval, and economic effects nationally and internationally. It is argued, therefore, that global climate change as a result of the increase of GHGs in the atmosphere has negative environmental and social effects (Bebbington & Larrinaga-Gonzalez 2008) as well as economic impacts (Busch & Hoffmann 2007; Labatt & White 2007; Sorensen & Pfeifer 2011). As a result, this phenomenon has created new risks and opportunities for a firm's executives and its stakeholders. These risks and opportunities can be classified to physical, regulatory, competitive and reputation, and litigation (Labatt & White 2007; Lash & Wellington 2007).

In response to this phenomenon, at least two new dimensions of corporate governance have emerged: carbon risk management and carbon disclosure. These two dimensions have become important features of corporate governance, and have arisen as a consequence of the pressure that has been exerted on firms to consider these new risks in their business decisions. Wittneben and Kiyar (2009) argue that climate change should be taken into consideration in business decisions for four reasons. First, political reasons, in which firms need to comply with political requirements such as GHGs emissions reduction. Second are economic reasons. For example, firms that consider climate change in their financial operations can help to convince rating agencies to provide a high rating to these firms, which in turn would

be reflected in the ease of attaining external finance. Third, public relations, where members of the community are expecting the firm to solve problems relevant to climate change rather than merely disclose these problems. Finally, first movers to new carbon markets can attain some financial benefits if they provide new products which accommodate the new market characteristics. Therefore, firms' efforts and management practices to tackle climate change associated risks could be value added activities. Nevertheless, several stakeholders argue the disclosure quality about carbon emissions and actions taken by firms to mitigate climate change associated risk is still low and invalid for comparability purposes (CERES 2009; Group 2007). Therefore, there is an increase in voices calling for more transparent, high quality, and unified standards for carbon and climate change disclosure (Reid & Toffel 2009; Smith, Morreale & Mariani 2008; Stanny & Ely 2008).

Yet, despite the importance of carbon emissions and the climate change phenomenon, limited research has examined how corporations deal and manage their potential exposure to this phenomenon, and how they disclose their performance in this area. Further, there is a dearth of studies that have investigated how investors are taking into account carbon risk management and disclosure in their decision making processes. Thus, because of the growing awareness about climate change and its effect on firms' risk profiles, and the lack of studies on this topic, the primary research question investigated in this research is:

To what extent are carbon risk management and carbon disclosure quality associated with the ex-ante cost of equity capital and market value?

The following sub-questions are designed to answer the main question:

1- *What is the direction and extent of the association between carbon risk management and carbon disclosure quality?*
2- *What is the direction and extent of the association between carbon disclosure quality and the ex-ante cost of equity capital and market value?*
3- *What is the direction and extent of the association between carbon risk management and the ex-ante cost of equity capital and market value?*

1.2 Definitions and research objectives

This study examines the interrelations between carbon risk management, carbon disclosure and the ex-ante cost of equity capital and firms' market value. This examination is performed using a cross-sectional sample of the global 500 (G500) firms in 2009. Hence, this research is built on two new constructs to achieve its objectives. These are carbon risk management and carbon disclosure.

1.2.1 Carbon risk management

For the purpose of this research, a comprehensive definition of *carbon risk management* (CRM) has been developed. This definition takes into account the carbon risk and management characteristics that have been identified in the literature. These include carbon emissions, risks, strategies, and opportunities. Lash and Wellington (2007) claim firms should follow four steps to improve their climate competitiveness. These steps are quantifying their carbon footprint, assessing carbon-related risks and opportunities, adapting the business in response to the risks and opportunities, and doing all this better than competitors. In addition, Hoffmann and

Busch (2008) provide a comprehensive framework that defines *carbon performance* based on four indicators in order to aid policy makers, investors, and financial institutions in their decision making. These indicators are carbon intensity[1], carbon dependency[2], carbon exposure, and carbon risk. Thus, carbon intensity and risks are considered important aspects that firms should quantify and measure in order to better manage them. Therefore, these aspects are appropriate for this research to develop an accurate CRM definition and measurement.

In addition to carbon intensity and risks, previous studies consider other forces that may influence carbon risk management. RepuTex (2008) offers a carbon valuation model that includes three factors representing a firm's overall carbon value. These factors are macroeconomic factors, carbon intensity, and micro firm analysis.

1- Carbon intensity analysis.

This analysis includes the firm's intensity and energy dependence within the product process across the entire value chain of its operation (scope 1, 2, and 3 emissions).

2- Macroeconomic factors.

Some macroeconomic factors act together to affect a firm's carbon value. According to PWC (2008), the direct and indirect business risks that stem from climate change have necessitated new carbon reduction laws. These laws have two side effects. On the one hand, they limit firms' emissions, which can result in a decrease in the impact of their operations on earnings (IGCC 2007). On the other hand, carbon-trading schemes are creating a carbon market, in which firms can sell permits and develop new sources of cash flows.

[1] Carbon intensity refers to the amount of carbon emitted by a company (scopes 1, 2, and 3) measured in metric tons divided by a business metric (revenues or sales).

[2] Carbon dependency occurs when a company's carbon intensity exceeds its carbon permits.

3- Micro firm analysis.

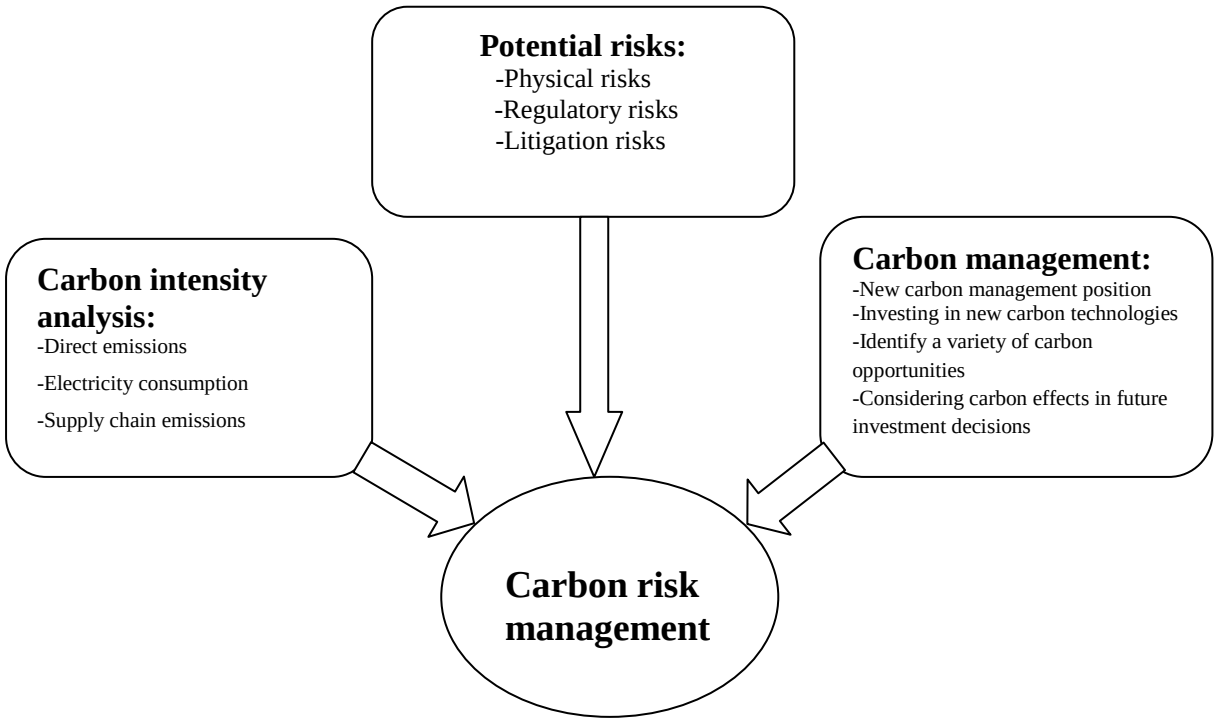
Assessing a firm's ability to deal with carbon risks is crucial in order to identify the added value to management teams. RepuTex (2008) claims that firms with a positive correlation between their energy exposure and ability to manage this exposure show a higher ability to abate this exposure, tackle risks, and deliver high returns. PWC (2008) provides a so-called Robust Carbon Management Framework to protect and enhance shareholder value. This framework offers the following series of steps for firms to follow in order to improve their value: create a new carbon management position, invest in new carbon reduction technologies, and identify new carbon market opportunities.

Moreover, Cora (2007) explains that some strategies, such as incurring some expenses (R&D) earlier than other firms, and adopting new pollution reduction programmes, can enhance the relationship between a firm and its stakeholders and consequently enhance the firm's value. These previous reports provide another aspect that firms should consider in their carbon activities, which is carbon management. Hence, the carbon management concept is also appropriate to this proposed study as it considers the subsequent step that firms should take to enhance their value.

To sum up, while some studies (e.g, Hoffmann & Busch 2008) have identified carbon intensity and risks as a key indicator of carbon performance, other studies refer to carbon management as a key determinant of future corporate governance. Therefore, this study integrates previous carbon characteristics into the development of the definition of *CRM* as follows (see figure 1.1): the firm's ability to estimate its historical and expected carbon intensity, identify potential carbon and climate

change risks and associated opportunities, actions undertaken or planning to undertake to minimise risks and maximise opportunities, and the firm's efficiency and effectiveness in managing these issues. Hence, for the purpose of this study, the better a firm's carbon risk management, the better its carbon and climate change performance.

Figure 1.1 Carbon risk management determinants



Source: Developed for this research.

1.2.2 Carbon Disclosure

For the purpose of this research, carbon disclosure refers to regulatory, physical and other risks and opportunities of climate change; greenhouse gas (GHG) emissions intensity and energy use; participation in emissions trading schemes; corporate governance and strategy in relation to climate change; and performance against GHG

emissions reduction targets. Hence, in this study it is defined as set of quantitative and qualitative information that relates to a firm's past and forecasted carbon emissions levels; its exposure to and financial implications of climate change associated risk and opportunities; and its past and future actions to manage these risks and opportunities. This information may be released via the firm's annual reports, stand-alone sustainability reports, via the firms' websites or through other dissemination channels such as the Carbon Disclosure Project (CDP). Based on this definition, this research relies more on the content, quality and informativeness of carbon disclosure than its quantity. This approach is espoused given that disclosure quality is more credible and informative for several stakeholders including stock market participants who are the third construct of this research than qualitative disclosure (Al-Tuwaijri, Christensen & Hughes 2004; Hughes, Anderson & Golden 2001; Orens, Aerts & Cormier 2010; Wiseman 1982). Carbon disclosure quality is captured by employing the CDP methodology (for more details see chapter 3). Finally, for the purpose of this research, all corporate reporting channels (annual reports, stand-alone sustainability reports, and corporate websites) will be referred to using the term 'sustainability reports'.

Previous two constructs as well as the stock market indicators are the main constructs that this study employs to reach its objectives.

1.2.3 Research objectives

Carbon disclosure is a type of environmental disclosure. Many empirical studies have examined the association between environmental performance and disclosure. However, no consistency has been achieved in these studies' results. On one hand,

some of the previous research has found a negative relationship, where inferior firms in terms of their environmental record have a high level of environmental disclosure (Cho & Patten 2007; Cormier, Ledoux & Magnan 2011; Hughes, Anderson & Golden 2001; Patten 2002). On the other hand, some other studies have observed a positive relationship between environmental performance and disclosure (Al-Tuwaijri, Christensen & Hughes 2004; Clarkson et al. 2008). Patten (2002) argues that this conflict stems from some shortcomings inherent in these studies' research designs. These shortcomings include failure to control for some factors recognised as disclosure drivers, inadequate sample selection, and weaknesses with environmental performance measures. In addition, different theoretical perspectives are used in previous research about environmental disclosure determinants. These can be broadly classified as socio-political theories and economic-based disclosure theories. Hence, the first objective of this thesis is to examine the association between carbon risk management and carbon disclosure. To this end, environmental disclosure determinants emanating from both sets of theories will be tested to investigate carbon disclosure determinants.

There is a long standing debate about the economic effects of undertaking environmental disclosure and performance activities. This debate is divided to two main streams. The first stream investigates theoretically and empirically the impact of environmental disclosure on cost of equity capital and market value (Clarkson et al. 2010; Dejean & Martinez 2009; Dhaliwal et al. 2011; Orens, Aerts & Cormier 2010; Plumlee et al. 2010; Plumlee, Brown & Marshall 2008; Reverte 2011; Richardson & Welker 2001; Richardson, Welker & Hutchinson 1999). The main argument explaining the link between disclosure level and economic benefits is that

investors rely extensively on firms' disclosures in their investment decision making. On the one hand, investors have incentives to possess a large amount of information to reduce the risk associated with investment decisions. On the other hand, firm managers are motivated to release more information to reduce the cost of capital associated with the finance required, and consequently to enhance their firms' market value.

The second stream examines the association between environmental performance and risk management on the cost of equity capital and market value (Clarkson et al. 2010; Connors & Sliva-Gao 2009; Sharfman & Fernando 2008). The potential impact of environmental performance on firms' economic prosperity is a contentious issue. Two terms have been used in these debates: 'win-win' and 'pays to be green' (Ambec & Lanoie 2008; Clarkson et al. 2011; Feldman, Soyka & Ameer 1997; Hart & Ahuja 1996). The proponents of the win-win concept claim that more stringent environmental regulations benefit micro and macro economies by increasing the competition between firms, and that this results in more innovations, productivity, and consequently profitability (Ambec & Lanoie 2008; Clarkson et al. 2011; Hart & Ahuja 1996; King & Lenox 2002; Porter & Linde 1995b, 1995a). In a sense, by adopting good environmental strategies, a firm can gain economic and social benefits while concurrently protecting the environment. The counter argument, however, is that the costs of green strategies are quite high for the economy (Palmer, Oates & Portney 1995), and investors perceive these costs as incremental costs that may erode firms' profitability (Cazavan-Jeny & Jeanjean 2006; Hassel, Nilsson & Nyquist 2005).

This research revisits this relationship in the context of carbon disclosure and risk management. Therefore, the second objective of this thesis is to examine the economic consequences (represented in the cost of equity capital and market value) of adopting carbon risk management and disclosure practices.

1.3 Research motivations and contributions

1.3.1 Motivations

The growing importance of and concerns about carbon emissions levels and climate change impacts provide three main motivations for this research. First, there is a limited understanding of the role of carbon in the modern business (Dembo 2008; Ratnatunga & Balachandran 2009). Hence, institutional investors and affiliated organisations such as Carbon Disclosure Project (CDP) and the Principal for Responsible Investment (PRI) can use this study to better understand how undertaken carbon risk management and disclosure practices manifest in a firm's cost of equity capital and market value. Indeed, it gives investors an aggregate understanding of stock market effects of adopting carbon risk management and disclosure activities. In addition, this study's results may help Non-Government Organisations (NGOs) such as the Climate Disclosure Standards Board (CDSB) and Global Reporting Initiative (GRI) in developing disclosure guidelines.

Second, this research is expected to help corporate regulators to understand the role of carbon information in the stock market. That is, the results of this study about the link between carbon risk management and disclosure and stock market indicators will help regulators in deciding whether the current carbon requirements are

effective in raising the minimum level of carbon risk management and disclosure activities or there is need to mandate these activities. Therefore, this study investigates carbon risk management and disclosure practices worldwide, and examines how capital markets react to such practices.

Third, a firm's management could assess the potential advantages and disadvantages of undertaking and disclosing carbon activities. This can be achieved by better understanding the anticipated effect of these activities on a firm's cost of equity capital and market value. Hence, the findings of this study may reveal which factors are useful in providing incentives for managers to adopt carbon risk management activities and to increase disclosure quality about these activities. Further, these results convey a message to firms' managers about the value relevance of undertaking carbon risk management and disclosure practices. Given these motivations, this study seeks to contribute to the knowledge about the economic impacts of carbon emissions and climate change in several ways.

1.3.2 Contributions

This study contributes to the literature on the association between environmental performance and environmental disclosure, and their impact on stock market performance, in several ways. First, this research extends prior environmental and carbon disclosure research by empirically investigating the link between carbon risk management and disclosure. Towards this end, this study utilises socio-political and economic-based disclosure theories as the theoretical framework to examine this association. Although few studies (e.g., Dawkins & Fraas 2011; Matsumura, Prakash & Vera-Muñoz 2011) have tested these theories in the context of carbon disclosure,

these studies have inherent methodological shortcomings such as variable measurement and sample problems. Hence, focusing only on carbon and climate change matters, and employing a broad and comprehensive measurement of performance and disclosure in new contexts (G500), allow for a more advanced test of whether environmental disclosure aligns with socio-political or economic-based disclosure theories.

Second, previous research has investigated a range of factors potentially associated with climate change disclosures including firm size, leverage, profitability, shareholder resolutions, regulatory threats, economic consequences, and several factors related to specific sectors and countries (Amran, Periasamy & Zulkafli 2011; Freedman & Jaggi 2005; Prado-Lorenzo et al. 2009; Reid & Toffel 2009; Stanny & Ely 2008). However, these studies have ignored carbon risk management and performance as a key determinant of carbon disclosure. Hence, this study may help in exploring the role of carbon risk management in shaping carbon disclosure practices.

Third, several stakeholders (regulators, institutional investors and environmental groups) have put pressure on firms that are potentially targeted by carbon constraints (such as carbon reduction laws) to incorporate carbon issues in their corporate governance (CERES 2003; Jeswani, Wehrmeyer & Mulugetta 2008; Sorensen & Pfeifer 2011). However, limited research has empirically investigated the impact of participating in some climate change endeavours on market value or stock returns (e.g., Beatty & Shimshack 2010; Chapple, Clarkson & Gold 2011; Gans & Hintermann 2011; Griffin, Lont & Sun 2011). Thus, this research contributes to an

understanding of a debate whether there is a relationship between carbon risk management and disclosure practices and investors assessments of these practices. Indeed, this study focuses on whether or not investors' risk perception of the firm changes as a result of adopting good carbon risk management and disclosure practices. Further, this study explores the reaction of capital markets to these practices by investigating a firm's market value after revealing information about carbon risk management practices. Particularly, this study extends the empirical literature about the economic consequences of improving environmental performance and disclosure practices, with an emphasis on carbon risk management and disclosure.

Fourth, this study contributes to the literature by developing comprehensive definitions and measures for carbon risk management and carbon disclosure (see chapter 3). This has been done in an attempt to avoid some of the methodological shortcomings inherent in previous research. Most of previous studies have relied on merely quantitative measurement as a proxy for environmental and carbon performance such as carbon and Toxic Release Inventory (TRI), or on the Kinder Lydenberg and Domini's (KLD) ratings which incorporates a broad definition of environmental performance rather than specific carbon and climate change aspects (Chapple, Clarkson & Gold 2011; Clarkson et al. 2010; Connors & Sliva-Gao 2009; Dawkins & Fraas 2011; Griffin, Lont & Sun 2011; Matsumura, Prakash & Vera-Muñoz 2011; Saka & Oshika 2010). Additionally, these studies have ignored some other aspects considered to be key performance indicators such as actions undertaken or that will be undertaken to reduce environmental and climate change risks. Moreover, some prior research has used either a binary approach or an event study

such as the announcement of participating in environmental or carbon actions to proxy for carbon disclosure (e.g., Beatty & Shimshack 2010; Dawkins & Fraas 2011; Saka & Oshika 2010; Stanny 2010; Stanny & Ely 2008). However, this research employs a comprehensive measurement that captures the quality and materiality of carbon disclosure. Furthermore, most previous studies have been conducted based on only one or two firm disclosure channels (annual reports, stand-alone environmental reports, or corporate websites). This study considers multiple potential information sources that may be used by a firm to communicate with outsiders.

Fifth, this research expands the literature about the role of particular carbon risk management activities in enhancing the disclosure about them. Specifically, this study investigates the importance and relevance of particular information relating carbon risk management to capital market participants. This is accomplished by disaggregating carbon risk management and disclosure scores to historical and future carbon risk management activities. Hence, this study assesses the validity of aggregating performance and disclosure scores in prior research.

Finally, most previous environmental research was performed in the USA and Europe, and on particular sectors which are considered to be environmentally-sensitive. This study, however, appears to be the first to use a global sample (G500 firms). Additionally, it covers all sectors and includes industry level analysis to examine differences in carbon risk management and carbon disclosure. Hence, this study's sample enhances its external validity, which, in turn, makes its conclusions more valid for generalisation and comparison purposes. Since this study is a cross-

country investigation, an overview of regulatory settings relevant to carbon disclosure is worthwhile.

1.4 Institutional settings

This research examines the impact of carbon emissions and climate change risk management and disclosure on stock market performance worldwide. The fundamental assumption here is that carbon disclosures are voluntary not mandatory. Hence, firms disseminate such information to gain some benefits rather than simply conforming to local laws and standards. Although different mandatory carbon regulations are in effect in some countries, these regulations focus merely on requiring the disclosure about carbon emissions rather than broad carbon and climate change information. Additionally, some of these regulations come into effect after the sample period of this research which is 2008.

In addition, several voluntary endeavours have been made in attempting to coerce firms to disclose carbon related information, and to find a unified framework to disclose this information. These endeavours are led separately and jointly by social and environmental activists and institutional investors. These initiatives include, to name just a few, the Climate Disclosure Standards Board (CDSB), Global Reporting Initiative (GRI), The Climate Registry's (TCR) voluntary reporting program, the CERES's 2006 global framework for climate risk disclosure, and the Carbon Disclosure Project (CDP). Therefore, this section explores the similarities and differences between carbon emissions and climate change disclosure practices across countries. This process informs the results of this research and provides a contextual framework. The countries of firms included in the sample for this research are

grouped into North America, European Union, UK, Asia and Pacific, and Others. The disclosure practices are discussed below for all these groups except for the Others group since it comprises only six firms from South Africa and Brazil.

North America

Several environmental regulations and standards have been enacted in the USA. These regulations require firms to operate in an environmentally responsible manner and to disclose their environmental activities. With regard to carbon disclosure, there were no mandatory laws at the federal level to enforce US firms to disclose such information until 2009. The United States Environmental Protections Agency's (EPA or sometimes USEPA) Proposed Mandatory Greenhouse Gas Reporting Rule was published in the Federal Register in April 2009. This proposal requires targeted firms to collect and report their GHGs emissions to the EPA from the calendar year 2010. Similarly, in 2010, the US Securities and Exchange Commission (SEC) issued interpretive guidance to public firms about how these firms should disclose carbon and climate change related information (SEC 2010). This action was in response to a petition to the SEC to issue new carbon and climate change disclosure guidance from a broad coalition of state officials with regulatory, law enforcement, and fiscal management responsibilities; some of the nation's largest institutional investors; and asset management firms.

This guidance identifies four themes from existing reporting requirement (items 101, 103, 303, and 503(c) of the S-K regulation). These themes considered to be applicable and relevant to include information regarding climate change. These themes are: the impact of existing and pending regulations regarding climate change;

the impact of international accords and treaties relating to climate change; indirect consequences of regulation or business trends-including legal, technological, political and scientific developments regarding climate change that may create new opportunities or risks; and the actual and potential physical impact of climate change. At a state level, several US states have separately mandated disclosure of GHGs emissions. The California Global Warming Solutions Act of 2006 (AB32) commits certain facilities in the State of California to annually report their GHG emissions to the California Air Resources Board.

Similar regulations to those of USA which require the disclosure of material issues exist in Canada. The national instrument 51-102 from Canadian Securities Administrators (CSA) requires all firms to disclose important matters, risks, commitments and uncertainties that would be material to investors, including environmental issues. This instrument is similar to item 103 of the S-K regulation in the USA (Griffin, Lont & Sun 2011).

In respect of carbon and greenhouse gas emissions, the government of Canada introduced the Greenhouse Gas Emissions Reporting Program (GHGRP) in 2004. This program requires all facilities which emit more than 50.000 tonnes of carbon to report their GHG emission using the Environment Canada's single window system. At a state level, several regulations are in effect which mandate the disclosure of carbon emission levels to the states' government.

To conclude, it is clear that there are some actions that have been taken by federal and state USA and Canadian governments to enforce carbon disclosure. However,

although some states have mandated some climate change disclosure, they require the dissemination of only one aspect of the climate change phenomenon which is GHG emissions. In addition, this information is required to be reported to the EPA in the USA and Environment Canada or other state agencies rather than to divulge it publicly. This may, to some extent, explain the weakness of carbon disclosure levels for US firms (Doran & Quinn 2009; Stanny 2010).

European Union

Complying with the Kyoto protocol, the European Union (EU) has spearheaded efforts to mitigate climate change and carbon emissions related risks. This is evidenced by the first carbon reduction scheme that is known as the European Union Emissions Trading Scheme (EU ETS). This scheme came into force in 2005, and mandated carbon reduction targets for all European Union members. This regulation was proposed based on three phases spanning the period from 2005 to 2012. According to this scheme, all EU members are required to report their emissions progress against the United Nations Framework Convention on Climate Change (UN FCCC) commitments to the EU commission. Reporting formats and guidelines are issued under European commission decision 2007/589/EC. This decision requires the largest EU firms to report on the six greenhouse gases controlled by the Kyoto protocol. Additionally, every two years, EU members should report their progress against the Kyoto targets (Aguiar 2009). At a national level, some EU members have introduced regulations that require the disclosure of environmental issues as well as GHG emissions. For example, in France, the Grenelle II (Law No. 2010-788 of 12 July 2010) requires firms to include in their annual reports a section on social and environmental consequences of their activities. In addition, this law requires these

firms to establish a greenhouse gas balance sheet before the end of 2012. To conclude, while there are some endeavours to establish carbon standards in Europe, most of these initiatives are voluntary and are focused just on carbon emissions levels.

UK

The common action that has been taken by the UK's government to address climate change and carbon emissions is the Climate Change Act 2008. This Act is recognised as the Carbon Reduction Commitment (CRC). This scheme, which entered into force by April 2010, aimed to reduce carbon emissions levels to 80 per cent by 2050. This act targets businesses that were not considered in the EU ETS. According to this scheme, firms are required to measure their energy use and emissions and report them to the government. However, the aim of this scheme is to reduce carbon emissions levels rather than being focused on emissions reporting per se. Therefore, it can be said that climate change and carbon emissions disclosure standards in the UK are still essentially voluntary.

Asia & Pacific

In Australia, The first National Greenhouse and Energy Reporting (NGERS) annual reporting period began on 1 July 2008. This Act requires particular firms to report their greenhouse gas emissions, energy production and consumption, and related information to the Department of Climate Change and Energy Efficiency. Despite the existence of this Act, the voluntary disclosure of carbon emissions in sustainability reports in Australia is still minimal and inconsistent (Cowan & Deegan 2011). Similarly, the Japanese' Ministry of Economy, Trade and Industry and

Ministry of the Environment has called particular firms to calculate their greenhouse gas emissions from FY 2006 and report it every year.

In summary, several disclosure initiatives have been enacted in the sample countries. While there are some mandatory disclosure requirements in some countries, most of these practices focus merely on reporting of greenhouse gases emissions to government agencies. In addition, there are no known regulations in the sample countries that require firms to disseminate this information as part of their normal disclosure practices. Therefore, it can be concluded that climate change related disclosure in annual and/or sustainability reports or on firm websites remains largely voluntary.

1.5 Structure of the research

The subsequent chapters of this research are organised as follows. Chapter two provides an overview of theories that are utilised to develop the hypotheses of this study. It also presents a review of relevant literature to this research. Chapter three describes the sample selection process; the data collection procedures and the data sources used in this study. In addition, it provides details of the measurement of dependent and independent variables, and justification for and measurement of control variables. It concludes with a presentation of the econometric models that are used to test this study's hypotheses. Chapter four presents the descriptive statistics for the dependent, independent and control variables. It also describes techniques used to mitigate outlier problems. Chapter five discusses the main results obtained from empirical tests. It starts with the correlation and regression results obtained from testing the relationship between carbon risk management and carbon

disclosure, as well as the results from sensitivity tests performed. Then, the correlation and regression results carbon disclosure, carbon risk management and the ex-ante cost of equity capital are discussed. Finally, this chapter presents the results from testing the association between carbon disclosure, carbon risk management and market value. Chapter six concludes this study with a discussion of its potential implications, limitations, and suggestions for future research.

CHAPTER 2 LITERATURE REVIEW AND HYPHOTHESES DEVELOPMENT

2.1 Introduction

A substantial body of prior research has focused on investigating the association between disclosures about environmental performance and measures of financial performance (Al-Tuwaijri, Christensen & Hughes 2004; Clarkson et al. 2008; Plumlee et al. 2010; Plumlee, Brown & Marshall 2008; Richardson & Welker 2001; Sharfman & Fernando 2008). This research includes theoretical and empirical studies. However, most prior studies have not incorporated the relatively new concepts of carbon emissions and climate change risk management and disclosure; which have recently begun to receive more attention from several groups of stakeholders including investors (Lash & Wellington 2007; Schultz & Williamson 2005; Smith, Morreale & Mariani 2008). This research seeks to provide evidence on the relationships between carbon risk management, carbon disclosure, and capital market effects.

The aims of this chapter are to explain the theoretical background of this study's hypotheses, review the literature relevant to these hypotheses, and state the hypotheses. This chapter is organised as follows: Section 2.2 reviews previous carbon studies and relevant research on the climate change phenomenon. Section 2.3 commences by describing the underlying theory of the relationship between carbon risk management and carbon emissions and climate change disclosure. It then reviews relevant prior research, and develops the related hypotheses. Section 2.4 provides a detailed overview of research on the linkage between disclosure levels and capital market effects. It then discusses the theoretical background for the

influence of carbon emissions and climate change disclosure on these effects. Next follows a review of prior work on this relationship and the development of relevant hypotheses. Section 2.5 outlines the theory explaining the relationship between carbon risk management and capital market effects; surveys prior research in this area; and states the related hypotheses. Section 2.6 illustrates the study's conceptual framework. Section 2.7 concludes the chapter.

2.2 Carbon and climate change literature

Most recent scientific reports have attributed climate change to the increasing levels of carbon emissions being released into the Earth's atmosphere (Dembo 2008; IPCC 2007; Prado-Lorenzo et al. 2009; PWC 2008). These reports have predicted that greenhouse gases (GHG) and specifically carbon dioxide (CO_2) will play an important role in future business in terms of growing concerns about the environment. Yet, in the accounting literature, studies about climate change generally, and carbon emissions specifically, remain limited. Relevant research in this area to date has separately focused on issues such as carbon management, climate change corporate strategies, and carbon disclosure trends and attributes (e.g., Chapple, Clarkson & Gold 2011; Doran & Quinn 2009; Freedman & Jaggi 2005, 2011; Kolk, Levy & Pinkse 2008; Prado-Lorenzo et al. 2009; Ratnatunga & Balachandran 2009; Reid & Toffel 2009; Stanny & Ely 2008; Weinhofer & Hoffmann 2008). This section overviews the prior research in this area, with the emphasis being on carbon management and disclosure, which most closely aligns with the major focus of this study.

In regard to studies of carbon and climate change strategies, Weinhofer and Hoffmann (2008) investigate the CO_2 strategies used by electricity firms in the European Union, Japan, and the United States. They find these firms embrace different long- and short-term CO_2 strategies. The strategies depend on firm size, firm location, and amount of CO_2 emissions generated. Ratnatunga and Balachandran (2009) review several carbon-related issues that firms should consider to protect their market positions. These issues are preparedness to perform in new carbon markets, investing in new carbon reduction technologies, and discerning future costs that may result from carbon regulations. Nevertheless, in spite of increasing attention being paid to climate change and its associated risks for business, their disclosures of these risks are still insufficient (Kolk, Levy & Pinkse 2008; Stanny 2010).

Previous studies in this area find that despite Standard & Poor (S&P) firms' understanding of the risks posed by climate change and their potential physical and financial impacts, information they provide about carbon emissions and climate change is limited (Doran & Quinn 2009; Stanny 2010). Kolk, Levy, and Pinkse (2008) also find that despite the increase of rates of response to the Carbon Disclosure Project's (CDP) questionnaire, the information provided in these responses does not meet investors, NGOs, or policy makers' expectations. Hence, this scarcity of carbon and climate change–related information has catalysed researchers to investigate the forces driving such disclosures.

With respect to the attributes of carbon disclosure behaviour, Freedman and Jaggi (2005, 2011) find that large firms from countries that ratified the Kyoto protocol tend

to disclose more pollution information than firms from countries that did not ratify the protocol. In addition, they show that disclosure practices of multinational firms differ depending on the location of their branches or home offices. Reid and Toffel (2009) find firms operating under carbon emission trading laws and firms in countries that are likely to issue new emissions-constraint laws have higher emission-disclosure levels than their counterparts in other countries. Stanny and Ely (2008) and Prado-Lorenzo et al. (2009) investigate several factors expected to drive corporate managers to disclose information about GHG emissions and the effect of climate change on their businesses. They find several factors that play a significant role in driving the disclosure of this type of information. These factors include a firm's size, previous participation in the CDP's questionnaire, cross-listed position, and presence of projected disclosure laws.

In summary, although there is an increasing awareness of climate change–related risks to businesses, their disclosure about these risks and their financial implications remains limited (McFarland 2009; Smith, Morreale & Mariani 2008). Little research has been conducted to investigate separately the impact of carbon emissions and climate change related disclosure and performance on firms' economic and financial performance. That is, no known holistic research that investigates the relationships between carbon emissions and climate change risk management and disclosure and their impacts on capital markets. The following sections visit each of these relationships by reviewing relevant theoretical perspectives and literature and developing related hypotheses.

2.3 Relationship between carbon risk management and carbon disclosure

This section focuses on the theory behind the development of hypotheses concerning the relationship between carbon risk management and carbon disclosure (these two terms are defined in chapter 1). To that end, a review of the relevant theoretical perspectives and literature is in order.

2.3.1 Theoretical background

This study draws on two dominant sets of theories that have been widely used in prior research to explain the relationship between a firm's performance (regardless of whether that performance is financial or non-financial) and its voluntary disclosure of that performance. These theories can be classified as (1) socio-political disclosure theories (i.e., legitimacy and stakeholder theories) and (2) economic-based disclosure theories (i.e., signalling and voluntary disclosure theories). The overlap between these theories in explaining the association between environmental performance and disclosure necessitates an overview of these theories (Clarkson, Overell & Chapple 2011; Deegan 2002).

2.3.1.1 Legitimacy theory

The legitimacy notion stems from the social contract concept (Cormier & Gordon 2001), in which a firm derives its legitimacy from the contract between it and society. Lindblom (1994, p. 2) (cited in Deegan 2002) describes *legitimacy* as 'a condition or status which exists when an entity's value system is congruent with the value system of the larger social system of which the entity is a part'.

Legitimacy theory assumes that a firm is operating within norms or standards that have been identified in the 'social contract' between the firm and the community (Deegan 2009; Deegan & Gordon 1996; Deegan & Rankin 1996; Gray, Kouhy & Lavers 1995; Patten 1991, 1992). Therefore, the firm is always trying to seek legitimacy, which is conferred by society based on the social contract between them. Once a firm feels its legitimacy is threatened, it pursues several strategies to retain this legitimacy. However, society's perspectives toward a firm's activity are unstable and change according to circumstances. Therefore, firm managers should always be able to recognise society's perspectives and respond to these perspectives appropriately to continue operating in an acceptable manner.

Four strategies have been identified by Lindblom (1994) and Gray, Kouhy, and Lavers (1995) that can be used by a firm to retain legitimacy or narrow the legitimacy gap. These strategies are:

(1) Educate the community about real changes in its performance.

(2) Change the community perception about its performance

(3) Deviate the community's attention from a particular issue to another related issue.

(4) Change the society members' expectations.

Given that firms usually feel threatened as a result of their poor performance, they release positive[3] (soft) information; not to fulfil stakeholders' right to know, but merely to refine their image and bridge the legitimacy gap (Cowan & Gadenne 2005;

[3] Deegan and Rankin (p. 56 1996) state: "Positive disclosures are defined as information which presents the company as operating in harmony with the environment"

Deegan & Rankin 1996; O'Donovan 2002). Therefore, soft or symbolic social and environmental disclosure can be used by a firm as a tool to deal with society's demands and needs (Freedman & Jaggi 2005; Lindblom 1994; Reverte 2009). Dowling and Pfeffer (1975) claim firms use communication in order to be seen to be meeting stakeholders' expectations.

By positive social and environmental disclosure, firms are signalling to several types of stakeholders that they are conforming to their expectations (Deegan & Gordon 1996; Deegan & Rankin 1996). Firms take this step to persuade stakeholders about their performance in order to maintain their legitimacy (Deegan & Gordon 1996). This behaviour can be explained by the following example: If a firm's operations have outcomes that fail to meet employee demands, government regulations, and supplier and consumer expectations, these failures exert pressure on a firm. This pressure can manifest in various forms, such as employee walkouts, stricter regulations passed by the government, consumer boycotts of products, or reduced availability of resources from suppliers. These firms release positive social and environmental information via annual reports (Branco & Rodrigues 2008; Cho & Patten 2007; Deegan, Rankin & Voght 2000; O'Donovan 2002) and corporate websites (Cho & Roberts 2010), to maintain legitimacy in the eyes of stakeholders.

In summary, when there is a lack of legitimacy resulting from the breach of social contracts, positive social and environmental disclosures in corporate reports are used to avoid social pressure and retain legitimacy. In addition, these disclosures may be used to enhance the corporate image. However, it is argued that legitimacy theory considers the whole society and ignores that society consists of several members

(stakeholders) with different powers, interests, and abilities to influence the activity of the firm (Deegan 2002). These different groups of stakeholders are considered in the argument of stakeholder theory. Thus, stakeholder theory is discussed in the following section.

2.3.1.2 Stakeholder theory

While legitimacy theory considers the overall society and its role in organisational legitimacy, stakeholder theory explains the role of particular stakeholders in shaping management strategies. According to Ullmann (1985) and Roberts (1992), stakeholders' power is an important factor that should be considered by a firm in order to manage its stakeholders. That is, the more power the stakeholders have, the more priority they should be given by a firm.

The departure point of stakeholder theory is that a firm is considered to be a part of a whole social system. This system consists of several parts that work together to achieve the system's targets. An important component of this system is the stakeholders, who interact with the firm to achieve their goals. Freeman (2001 p. 59) states, 'Corporations have stakeholders, that is, groups and individuals who benefit from or are harmed by, and whose rights are violated or respected by, corporate actions'. Therefore, as the firm strives to achieve its objectives, it affects and is affected by its stakeholders.

Stakeholder theory has two branches: the normative (moral or ethical) branch and the managerial branch (Deegan 2009; Hasnas 1998). These two branches are quite similar to the two variants identified by Gray, Owen, and Adams (1996): that is,

accountability and power. The normative branch of stakeholder theory posits that a firm should act and deal equally with all of its stakeholders' interests regardless of their power. This assumption emphasises that, in the case of conflicts between stakeholders' expectations, the firm should sacrifice the interests of particular stakeholders to other stakeholders to treat them equally (Hasnas 1998).

In its managerial branch, stakeholder theory assumes a firm stands in the centre and is surrounded by different stakeholders with different power and interests. Therefore, the firm's management should properly identify and manage powerful stakeholders to ensure continued survival. The firm's reaction to specific stakeholders varies widely depending on the power they have over the firm (such as the supply of resources) (Deegan & Blomquist 2006; Ullmann 1985). That is, the more important the stakeholder to the firm, the more consideration is given to managing and dealing with this stakeholder (Gray, Owen & Adams 1996).

Firms use reporting practices as a means to deal with their stakeholders' expectations. Under the normative branch, firms focus on a broad range of stakeholders and their various information needs (Gray, Owen & Adams 1996). In contrast, under the managerial branch, firms' management uses disclosure as a tool to deal only with the informational needs of the various powerful stakeholder groups (Bailey, Harte & Sugden 2000; Reverte 2009). Nevertheless, despite this conflict in the importance of particular stakeholder to a firm's survival, legitimacy theory and stakeholder theory (with its two branches) posit that disclosure practices are an important instrument that could be used by a firm to maintain its legitimacy and to meet its stakeholders' expectations.

With respect of the relationship between environmental performance and disclosure, these theories posit that firms with poor environmental performance tend to selectively disclose more positive (unverifiable) information about their performance. Indeed, because of their poor performance, these firms resort to releasing soft or symbolic information to modify their public image (Clarkson, Overell & Chapple 2011). Firms behave in this way in order to mitigate potential lawsuit costs and change stakeholders' perceptions about real performance (Clarkson et al. 2008; Leuz & Wysocki 2008; Patten 2002). In addition, firms that experience environmental incidents tend to release positive (or qualitative) information at or after the time of the environmental incident (Deegan & Rankin 1996; Deegan, Rankin & Voght 2000).

Based on the previous discussion, legitimacy and stakeholder theories assume a negative relationship between environmental performance and disclosure. Inferior firms in terms of environmental performance are motivated to disseminate more positive 'soft' information. This action is taken by a firm in order to 1) maintain its legitimacy within its context, and, 2) to divert powerful stakeholders' perceptions from the actual poor environmental performance.

Having discussed these two theories, it could be said that they are considered appropriate for explaining the association between carbon risk management and carbon disclosure quality. The propensity of firms with poor carbon risk management records to divulge positive information is higher than firms with a good carbon risk management record. That is, once firms recognise that their carbon legitimacy is threatened because of their high carbon intensity, or less actions

undertaken to tackle climate change risks, they release more positive (soft and unverifiable) information about their actions taken to deal with these emissions. This process is followed in order to maintain carbon legitimacy, positively influence stakeholders' perceptions, and avoid potential litigation problems.

Although they are widely used in previous research, there are a few limitations inherent in socio-political theories. First, legitimacy theory is derived from bourgeois political economy theory (Deegan 2009; Gray, Kouhy & Lavers 1995). This implies that this theory cannot be applied to contexts in which the stock market does not exist or in which family or government ownership dominates the firm's finance practices (Lopes & Rodrigues 2007). Second, the normative branch of stakeholder theory seems to conflict with the wealth maximisation principle. Fulfilling all stakeholders' expectations equally might conflict with the expectations of one very important stakeholder—the shareholders (or stockholders) (Jensen 2002). Third, the managerial branch of stakeholder theory explains disclosure practices only from the managers' perspectives and, thus, ignores the disclosure context, including location. It ignores, for instance, the role of governments and states in determining disclosure practices within firms they own. Finally, stakeholder theory fails to provide an adequate explanation of the phenomenon of nondisclosure by some firms in the same industry or within the same context (Freedman & Jaggi 2005). Therefore, these shortcomings lead to other theories which offer a broad explanation of environmental disclosure practices. The next section discusses the set of theories classified as economic-based disclosure theories, including signalling theory and voluntary disclosure theory.

2.3.1.3 Signalling theory

Signalling theory was developed to explain the 'lemons' (or information asymmetry) problem. This problem occurs as a result of information asymmetry between a firm's management and its current and potential investors (Healy & Palepu 2001). Hence, the most important task of disclosure is to mitigate information asymmetry. Signalling theory suggests that firms with a record of good performance signal this record to outsiders to reduce information asymmetry, or to influence external perceptions about a firm's reputation (Akerlof 1970; Levin 2001; Morris 1987; Ross 1977; Toms 2002).

According to Morris (1987), the signalling process occurs when the product sellers disseminate information about their product's quality to buyers to raise their product price and reduce asymmetry and adverse selections problems. Buyers in this case translate this information and interpret it as evidence that other products are poor quality. This behaviour can also be applied to the stock market. The signal depends on the relationship between firm managers and current and potential shareholders: the degree of investor monitoring determines the degree of firm signalling (Jensen & Meckling 1976). That is, the more scrutiny a firm receives, the higher the disclosure level will be (Stanny & Ely 2008). Signalling behaviour is undertaken by managers to mitigate information asymmetry and enhance their firm's reputation (Toms 2002).

Managers can use several strategies to signal their performance quality. These strategies include the dividends distribution announcement (Bhattacharya 1979) and the structure of the board of directors for firms undertaking initial public offerings (IPOs) (Certo 2003). However, these strategies should be taken in the presence of the

signalling cost concept. Bhattacharya and Dittmar (2004) argue that good firms can choose one of two signalling methods: the costless or the costly signalling method. Costless technique (cheap talk) is used by undervalued firms to receive more attention, whereas, costly signalling is used by good performers since this technique cannot be imitated by poor performers. Hence, to be effective, the signal must not be easily copied by another firm and must conform to the actual quality of the firm (Morris 1987). This can be accomplished by 'hard' disclosures (Clarkson et al. 2008), whereby superior firms in terms of environmental performance signal their performance quality using objective measures. This claim is in line with voluntary disclosure theory's assumption.

2.3.1.4 Voluntary disclosure theory

Voluntary disclosure theory (Verrecchia 1983; Dye 1985; Clarkson et al. 2008) assumes that superior firms are motivated to release information about their good performance practices to differentiate themselves from inferior firms. Firms' managers commit to such behaviour to avoid adverse selection problems, or to mitigate undervaluation consequences (Healy & Palepu 2001).

To achieve their aims from this behaviour, good performers reveal verifiable or actual information about their environmental performance. This type of information should be difficult to imitate by a firm's counterparts and competitors. On the other hand, poor performers prefer to be silent about their performance if outsiders are unable to recognise whether the withholding of performance information stems from poor performance or from high proprietary costs (Verrecchia 1983).

Given their similarities in explaining the disclosure phenomenon, signalling and voluntary disclosure theories can be applied to explain carbon disclosures. Firms with good carbon risk management practices have incentives to signal these good practices to the stock market. One such incentive is firms' desire to reveal this information to mitigate information asymmetry problems (signalling theory). For instance, some firms might decide to disclose information about their exposure to climate change risks and how they have prepared to mitigate these risks to attract more investors and consequently enhance their share price.

In addition, by disseminating this information, superior firms in terms of carbon risk management hope to distinguish themselves from inferior firms and thereby gain economic benefits (voluntary disclosure theory). This can be accomplished through hard disclosures (Clarkson et al. 2008), whereby superior firms signal their carbon risk management objectives more effectively than do inferior firms. Firms with a low carbon profile, for example, or that have energy efficient technologies, divulge information about these facts to enhance their competitive advantage and share value. These benefits can be gained because informed investors consider these firms less risky (Botosan 1997; Cormier & Magnan 1999; Sengupta 1998). In addition, by providing information about their preparedness for competing in new carbon markets, these firms can enhance their present value (Richardson, Welker & Hutchinson 1999). Hence, signalling and voluntary disclosure theories predict a positive relationship between environmental performance and environmental disclosure. This prediction can be extended to assume a positive association between carbon risk management and disclosure. That is, the better the carbon risk

management practices, the higher the quality of information released about these practices.

In summary, the association between environmental performance and environmental disclosure can be explained by one of two theoretical perspectives, socio-political theories, or economic-based disclosure theories. Both of these theories can be used to explain voluntary disclosure, but they rely on different explanations for disclosure type (Clarkson, Overell & Chapple 2011). While they agree in that carbon risk management is a key driver of environmental disclosure, they disagree on the type of disclosure. On one hand, socio-political theories assume that firms with poor carbon risk management practice disclose soft and qualitative disclosure to maintain their carbon legitimacy and refine their public image. On the other hand, economic-based disclosure theories propose that firms with good carbon risk management records release hard and high quality information to differentiate themselves from poor firms, and reap some economic benefits. Hence, both of these two sets predict a positive relationship between carbon risk management and the use of hard and soft disclosures. Given the different perspectives between these two sets of theories, it is not surprising that prior research conducted to explore the association between environmental performance and disclosure has provided mixed results. Many prior empirical studies were conducted in order to understand disclosure determinants while concurrently testing just one of these theories. The next section reviews these studies in detail.

2.3.2 Prior research on the relationship between carbon risk management and carbon disclosure

The differences in previous results can be attributed to several reasons. First, previous research has adopted different theoretical frameworks which have different predictions. Second, this body of research has experienced some research design problems. One of these problems is the failure to control for some factors influencing disclosure such as firm size and industry affiliation. Additionally, previous studies suffer from sample selection problems as well as insufficient environmental performance and disclosure measures (Brammer & Pavelin 2008; Patten 2002; Ullmann 1985).

On one side, Hughes, Anderson, and Golden (2001) observe different environmental disclosure levels between US firms whose performances are rated good, mixed, and poor. They conclude that while the disclosure content does not emphasize actual performance, firms rated as poor performers provide more environmental disclosure. These firms received more scrutiny after the issuance of some disclosure standards such as SFAS NO. 5 and FASB, 1975 (Hughes, Anderson & Golden 2001). In addition, Patten (2002) finds that firms with high levels of toxic releases are more likely to disclose them. He justifies this result by explaining that these firms are more exposed to political and social pressures. Cho and Patten (2007) find that, consistent with legitimacy theory, financially quantified environmental disclosures of poor environmental performers in environmentally sensitive industries are higher than those of better performers.

Further, Cho, Freedman and Patten (2009) find that, in support of legitimacy theory, inferior environmental performers (based on TRI emissions) are more likely to disclose environmental capital spending relative to superior firms. Moreover, Cormier, Ledoux, and Magnan (2011) and Dragomir (2010) support Patten's (2002) results by concluding that high polluters tend to disclose more information about their pollution levels than low polluters. They claim their results are consistent with legitimacy theory. The discussion so far suggests that much research has provided support for socio-political theories (especially for legitimacy theory). Firms provide more disclosure to repair their legitimacy. However, there is another stream of research which has found converse results.

Al-Tuwaijri, Christensen, and Hughes (2004) study the interrelation between environmental disclosure, environmental performance, and economic performance. In terms of the relationship between environmental performance and environmental disclosure, they conclude that, consistent with discretionary voluntary disclosure theory, firms with good pollution performance tend to disclose more about this performance. Additionally, Clarkson et al. (2008) revisit this relationship and consider voluntary disclosure theory and socio-political theories. They test the impact of objective environmental performance claims, which cannot be imitated by poor performers, and of subjective environmental performance claims on the level of disclosure. Clarkson et al. (2008) find that, consistent with voluntary disclosure theory, there is a positive relationship between environmental performance and the total environmental disclosures on a firm's website or in its environmental and social reports. However, they conclude that socio-political theories (especially legitimacy theory) are still valid in explaining the 'soft' disclosures made by poor

environmental performers. In a more recent study, Clarkson, Overell and Chapple (2011) affirm the existence of a positive association between environmental performance and disclosure in the Australian context. While most prior research was conducted based on broad environmental performance and disclosure concepts, few studies have been conducted specifically on carbon disclosure determinants.

Dawkins and Fraas (2011) examine the association between environmental performance and climate change disclosure based on defensive and accommodative approaches. The assumptions of these two approaches' are quite similar to those of socio-political and economic disclosure theories. Where the former posits a negative relationship similar to the defensive approach, the latter assumes a positive relationship similar to the accommodative approach. Dawkins and Fraas (2011) affirm the positive relationship between environmental performance and climate change disclosure. Similarly, Matsumura, Prakash and Vera-Muñoz (2011) find that superior environmental performers provide more carbon emissions information than inferior performers do.

While the theoretical perspectives and empirical results discussed so far affirm the existence of a relationship between environmental performance and disclosure, they consider this relationship from different sides. The main disagreement is that the quality of this disclosure in these theories is different. While socio-political theories assume that inferior firms resort to soft disclosure to refine their image, economic-based disclosure theories posit that superior firms choose to release objective information which is difficult to mimic about their performance (Clarkson, Overell & Chapple 2011). Hence, the premise of these sets of theories concurs about the

existence of positive association between environmental performance and disclosure but they differentiate between the types of disclosure (Clarkson, Overell & Chapple 2011). That is, socio-political theories assumes that the worse the environmental performance the higher the soft and qualitative disclosure, whereas economic-based disclosure theories posit that the better the environmental performance the higher the quality of environmental disclosure. By applying these theories to the context of this research, vice versa, the better the carbon risk management the higher the quality of carbon disclosure. Thus this study hypothesises that:

H1 - There is a positive relationship between carbon risk management and the quality of carbon disclosure.

2.4 Relationship between carbon disclosure and capital market indicators

This section develops two sub-hypotheses that link carbon disclosure with capital market indicators, the ex-ante cost of equity capital and market value. The existence, direction, significance, and underlying mechanism of these relationships remain key debates in the literature. However, it is helpful to review the literature regarding the link between disclosure levels generally and financial performance before narrowing the focus to the carbon disclosure. This review elucidates the theoretical and empirical debate regarding the impact of information on firms' financial performance.

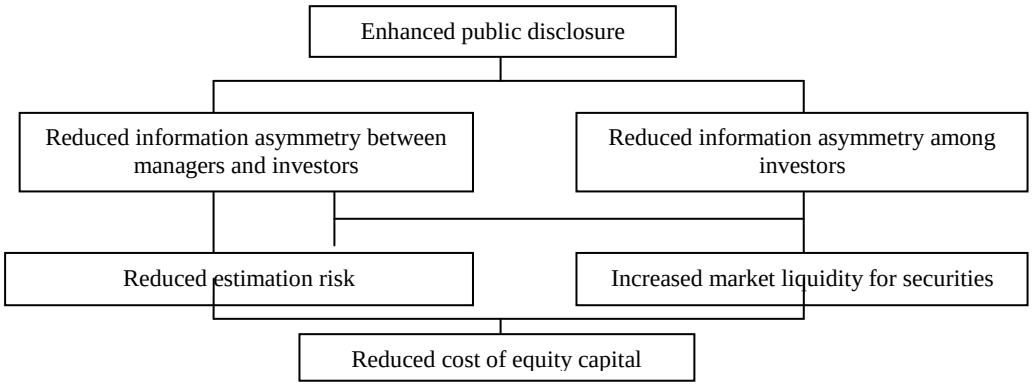
2.4.1 Economic benefits of disclosure practices

Prior research has focused on a variety of issues related to financial disclosure (e.g., Botosan 1997; Botosan & Plumlee 2002; Hail 2002; Lang & Lundholm 1996; Leuz & Verrecchia 2000; Richardson & Welker 2001). Most of this literature has focused on the economic benefits of disclosure practices. In particular, previous studies have examined the impact of disclosure level on ex-ante cost of equity capital and market value.

The relationship between disclosure and cost of capital has become an important issue in modern economies with respect to the role of information in evaluating potential investments. There is a high degree of consensus among researchers in this area, suggesting that increased disclosure is negatively associated with the cost of equity capital (Amihud & Mendelson 2008; Botosan 2006; Collett & Hrasky 2005). Despite this consensus, there is a paucity of evidence about the mechanism of this relationship (Leuz & Wysocki 2008). Therefore, there are rival explanations about the role of disclosure in reducing the cost of equity capital. Most of these explanations contend that an enhanced disclosure level leads to a reduction in estimation risk and/or increased market liquidity for the firm's securities (see figure 2.1).

Many studies have investigated this relationship theoretically. Diamond and Verrecchia (1991) claim enhancing disclosure policies reduces information asymmetry. This action increases traders' willingness to acquire a firm's shares, which in turn increases liquidity and consequently decreases the cost of equity capital.

Figure 2.1 Disclosure benefits framework



Source: (Botosan 2000)

Easley and O'Hara (2004) develop a model that explains the role of information in allocating the cost of capital. They demonstrate that the rate of return that investors require on their investment is based on the information quality and quantity they have about the firm. Informed investors require a lower rate of return on their investments, whereas uninformed investors require a higher rate of return to compensate for the investment risk premium that results from a lack of information. Lambert, Leuz, and Verrecchia (2007) develop a framework to link the disclosure of accounting information to the cost of equity capital. They propose that the quality of accounting disclosure influences the cost of capital directly through the reduction of estimation risk, and indirectly through changing management decisions.

In addition, disclosure level and its economic consequences have been widely examined within and across countries. Botosan (1997) investigates this relationship in the United States. She finds that, for firms with a low analyst following, precise disclosure is associated with a lower cost of equity capital. For firms with high analyst following, there is no significant relationship between disclosure level and cost of equity capital. Botosan and Plumlee (2002) re-examine the relationship between cost of equity capital and three types of disclosure: annual reports, quarterly

reports, and other published reports and investor relations. They find the cost of equity capital decreases with the annual report disclosure level. In contrast to their expectation, they find there is a positive relationship between the cost of equity capital and more timely disclosures.

Richardson and Welker (2001) study the relationship between financial and social disclosure quality and the cost of equity capital in Canada based on Botosan's (1997) work. Richardson and Welker support Botosan's findings that the relationship between financial disclosure and the cost of equity capital is significantly negative for firms with a low analyst following. In a more recent study, Artiach (2009) examines the individual and joint impact of conservative financial reporting and disclosure on the cost of equity capital. She suggests firms that have adopted conservative disclosure policies experience a reduction of the cost of equity capital. It is argued, however, that attributing additional economic benefits to increased disclosure is difficult to observe in the US context, where disclosure standards are considered complex and strict (Healy & Palepu 2001; Leuz & Verrecchia 2000). Hence, this relationship has also been examined in Europe.

Leuz and Verrecchia (2000) test whether German firms that committed to increase disclosure levels, experience a decrease in the cost of equity capital. They provide more evidence that firms maintaining high disclosure levels accrue greater economic benefits in the form of lower bid-ask spreads and higher share turnover. Hail (2002) examines this relationship in Switzerland and demonstrates that there is an inverse and highly significant relationship between the level of disclosure and the cost of equity capital.

Further, some multi-country research has been conducted to investigate this relationship. Francis, Khurana and Pereira (2005) test disclosure incentives and their influence on the cost of capital in 34 countries. They find firms that require external financing are more likely to increase their disclosure level, which is consequently reflected in a lower cost of debt and equity capital. Hail and Leuz (2006) find that firms from countries that have stringent disclosure requirements and stock market rules experience lower cost of equity capital than firms from countries that do not.

Kristandl and Bontis (2007) investigate this relationship in four European countries (Austria, Germany, Sweden, and Denmark). They find a conflicting relationship between historical and forward disclosures and the cost of equity capital. While there is a negative relationship between 'forward-oriented information' and the cost of equity capital, historical disclosure is positively associated with the cost of equity capital. Previous results about the impact of disclosure standards have been supported by Sami and Zhou (2008). They find Chinese firms with high disclosure standards that list in China and other countries experience a reduction in the cost of capital and thus high market value compared with other domestic firms.

The discussion thus far suggests that firms can gain economic benefits from improving their disclosure practices. Nevertheless, previous studies have been prone to three dominant criticisms. First, they are faulted for methodological weaknesses because the level of disclosure and the cost of equity capital are difficult to measure directly (Hail 2002). Second, as mentioned above, the difference in disclosure standards between countries makes the generalisation of particular findings to all contexts questionable. Finally, previous studies have investigated this relationship

from different angles and by controlling different factors. For example, Botosan (1997) find that the negative association between disclosure level and the cost of equity capital is conditional on analyst followings; whereas Francis, Nanda and Olsson (2008) and Artiach (2009) find that this negative relationship is dependent on earnings quality and conservatism practices.

To sum up, previous investigations are based on several assumptions and use a variety of approaches and methods to understand this relationship. Although there are differences between the underlying mechanisms that compete to explain the relationship between disclosure levels and cost of equity capital and market value, most previous studies empirically or theoretically assert there is a negative relationship. This consensus has triggered researchers to investigate this relationship in specific contexts, such as social and environmental disclosures. The next section discusses the theoretical foundation pertaining to the association between carbon disclosure and stock market indicators.

2.4.2 Theoretical background for the relationship between carbon disclosure and the ex-ante cost of equity capital and market value

This section focuses on developing hypotheses that link carbon disclosure with the ex-ante cost of equity capital and market value. The underlying mechanism of the linkage between environmental disclosure and the cost of equity capital is assumed to be similar to that between financial disclosure and the cost of equity capital. This mechanism is that higher quality disclosure leads to a reduction in estimation risk and/or increased market liquidity through a reduction in information asymmetry regarding the firm's securities.

Similarly, in regard to environmental disclosure, the underlying assumption is that investors use environmental information in their decision making. This is consistent with Cormier, Ledoux, and Magnan's (2011) argument that social and environmental disclosures can substitute for each other and enhance stock market symmetry. Moreover, Cormier, Magnan, and Van Velthoven (2005) argue that higher environmental disclosure quality reduces the information asymmetry between firms and investors, hence reducing the costs that investors may incur retrieving this information from alternative sources. Consequently, this results in a reduction of the cost of capital.

2.4.2.1 The Lambert, Leuz, and Verrecchia's (2007) Model

The main argument explaining the link between disclosure level and economic benefits is that investors rely extensively on firms' disclosures in their investment decision making. Accordingly, accounting information is considered essential for both investors and firms' managers. On the one hand, future investors have incentives to possess a large amount of information to reduce the risk associated with investment decisions. Foster (2003) argues a higher level of disclosure reduces the uncertainty level and consequently reduces the risk and the rate of return that investors demand. On the other hand, firm managers are motivated to release more information to reduce the cost of capital associated with the finance required, and consequently to enhance their firms' market value.

In relation to nonfinancial information, Branco and Rodrigues (2008, p. 686) point out, 'Some companies believe that being seen as socially responsible will bring them a competitive advantage, allowing them to achieve better economic results'.

Therefore, investors call for precise and transparent environmental information to adequately process their investment's decisions (Cormier & Magnan 2007; Orens, Aerts & Cormier 2010; Plumlee, Brown & Marshall 2008). This better quality of information reduces the required rate of returns since investors can adequately estimate the firm-specific information (Diamond 1985; Diamond & Verrecchia 1991; Lundholm & Van Winkle 2006).

In this vein, Lambert, Leuz, and Verrecchia (2007) (hereafter LLV) build a theoretical framework that links the voluntary disclosure quality with the cost of capital, which is defined as the expected rate of return. This model predicts that information quality has an impact on cost of capital through its effect on expected cash flows or through estimation risk or both. This framework demonstrates that information has direct and indirect impacts on the cost of capital. Information quality can affect the cost of capital directly through reducing estimation risk. That is, the ability of investors to access private information reduces the risk and uncertainty of their decisions. This reduction is consequently reflected in demanding a lower rate of return.

In addition, the indirect impact of information on cost of capital can be attributed to the decrease of cost of capital, which has resulted from the direct effect, increases the opportunity set of positive net present value projects. This reduction will increase future cash flows of disclosed firms (by changing a firm's real decisions) compared to non-disclosed firms. LLV (2007) state:

> 'The indirect effect occurs because higher quality disclosures change a firm's real decisions. As a consequence, the ratio of a firm's expected future cash flows to the covariance of these cash flows with the sum of the cash flows of all firms changes'.

Previous analysis implies that there is a positive relationship between disclosure level and cash flows. Thus, cash flows are considered a key determinant of the cost of capital (Lambert, Leuz & Verrecchia 2007).

This model seems appropriate for explaining the relationship between carbon disclosure and the ex-ante cost of equity capital and market value for two reasons. First, firms that choose to disclose more information about their carbon risk management are doing so to inform investors about this management. Hence, this information reduces the estimation risk and helps investors to be more confident in deciding to invest in these firms. This is expected to lead investors to require lower rates of return on their investments. In the absence of information about carbon risk management activities, investors may require higher rates of return to compensate for the uncertainty and risk (Botosan 2000). Thompson and Cowton (2004), for instance, find that 87 per cent of UK banks consider environmental risk issues in lending decisions. They claim these banks may withhold loans to firms with poor environmental records or high exposure to environmental concerns.

Second, an indirect effect occurs where firms with high carbon disclosure quality employ the cost savings that have resulted from the direct effect (the reduction of cost of capital) in new carbon reduction projects and initiatives. Revealing information about these projects helps a firm increase its cash flow compared with non-disclosing firms in two ways: (a) these new projects assist a firm in increasing its earnings with regard to the reduction of carbon costs (decrease of electricity consumption, trading in new carbon technologies, and so on), and (b) disclosure about these projects attracts more investors, which enhances the liquidity of shares of

disclosing firms. That is, more disclosure reduces the information asymmetry problems and the cost of external finance (Verrecchia 1983) and consequently enhances firms' ability to invest in new, profitable projects (Bushman & Smith 2001).

The preceding discussion is consistent with the argument of Richardson, Welker, and Hutchinson (1999) that the market effects of social responsibility disclosure fall into three areas: market process effects, cash flow effects, and investors' discount-rate effects. First, market-process effects occur as a result of releasing environmental information. This disclosure reduces the information asymmetry and consequently enhances the firm's market liquidity, which leads in turn to a reduction in the cost of capital. Second, cash flow effects can be identified from the fact that revealing information about future environmental projects enhances the net present value of these projects. This emerges because investors may consider the cost of these projects as value maximisation costs, which simultaneously improves the firm's environmental and financial performance. Finally, Richardson, Welker, and Hutchinson (1999) argue that, regardless of the cash flow effects, some investors may prefer to invest in firms that are performing well in terms of environment issues. Therefore, those investors demand a lower rate of return from these firms compared with other firms.

To conclude, there are some theoretical endeavours to explain the phenomenon of capital market responses financial and non-financial disclosures. These endeavours argue that enhancing disclosure practices reduces information asymmetry problems between a firm and stock market participants. This leads to reduction in the costs that

investors bear in attempting to obtain this information. The reduction of these costs results in a reduction in the rate of return required by investors. All of the preceding theoretical arguments have been empirically examined jointly and separately, and the results of these studies are reviewed in the next section.

2.4.3 Prior research on the relationship between carbon disclosure and stock market performance indicators

Several prior studies and reports claim that firms' stakeholders have put pressure on firms to improve their performance regarding GHG emissions and disclosures (Hoffmann & Busch 2008; Lash & Wellington 2007; PWC 2008). Meanwhile, there is limited research on the nature of the relationship between firms' stakeholders and CRM and its disclosure. Therefore, the remainder of this literature review draws on previous studies of environmental performance and disclosure as they relate to the research topic.

The nature of the relationship between environmental disclosure and financial performance is debatable. Several studies have examined this relationship by investigating the impact of environmental disclosure on market performance indicators, such as cost of equity capital and firm value (Clarkson et al. 2010; Cormier & Magnan 2007; Dedman et al. 2008; Dhaliwal et al. 2011; Moneva & Cuellar 2009; Orens, Aerts & Cormier 2010; Plumlee et al. 2010; Plumlee, Brown & Marshall 2008; Ragothaman & Carr 2008; Richardson & Welker 2001). Regarding the relationship between environmental disclosure and the cost of equity capital, most previous studies have reached inconclusive results due to differences in their

research methods and theoretical approaches (Moneva & Cuellar 2009; Richardson & Welker 2001).

Richardson and Welker (2001) investigate relationship between financial and social disclosure and the cost of equity capital in Canada. Consistent with their prediction, a negative association between financial disclosure and the cost of equity capital is found. In contrast, they find a positive association between social disclosure (including environmental disclosure) and the cost of equity capital, in which more profitable firms are penalized more for their social disclosures. This conflict result could be justified as Richardson and Welker (2001) do not consider the actual environmental performance in their study (Clarkson et al. 2010).

Plumlee, Brown, and Marshall (2008) and Plumlee et al. (2010) examine the impact of environmental disclosure quality on the firm's value in the US context. They conduct their study by dividing market value into its two components: the cost of equity capital and future cash flows. They document a negative relationship between the quality of environmental disclosure and the cost of equity capital in firms that belong to environmentally sensitive industries. Orens, Aerts and Cormier (2010) investigate this link in a comparison study between North America and Europe. They detect a negative association between non-financial disclosure made via firms' corporate websites and the cost of equity capital in these two contexts

More recently, Dhaliwal et al. (2011) study the impact of voluntary disclosures of corporate social responsibility performance on the cost of equity capital. They find firms with a high cost of equity capital are reporting their corporate social

responsibility performance to benefit from reducing the cost of capital. In the same way, firms with high corporate social responsibility performance experience a reduction in the cost of equity capital through high levels of disclosure. Likewise, Reverte (2011) observes that, in general, Spanish firms with high corporate social responsibility disclosure ratings experience a reduction in their cost of equity capital. However, this reduction is more pronounced in environmentally sensitive industries. While most prior research documents a positive or negative association between environmental disclosure and the cost of equity capital, there are some studies that have not observed a significant relationship.

Dejean and Martinez (2009) do not detect any reduction in the cost of equity capital as a consequence of improving environmental disclosure practices in the French context. In addition, Clarkson et al. (2010) examine the association between environmental disclosure and firm value in the US context. They find that voluntary environmental disclosure has no role in the allocation of either the cost of equity capital or firm value. Clarkson et al. (2010) interpret these results as indicating that investors do not consider any incremental disclosures beyond those required by the Environmental Protection Agency (EPA) in making their investment decisions.

Whilst previous studies have focused on the cost of equity capital benefits, some other research has resorted to exploring the link between social and environmental disclosure and firms' market value. This stream of research is in line with Richardson, Welker and Hutchinson's (1999) claim about the market effect of social and environmental disclosure (see section 2.3.2.1).

Studies of market reactions to environmental information illustrate that market participants react to some environmental disclosures, especially if environmental regulations are anticipated. In this regard, Lorraine, Collison, and Power (2004) and Freedman and Patten (2004) find the market reacts negatively to environmental information about firms with low environmental performance. The negative association is greatest for firms potentially targeted by environmental regulations or that received fines as a result of pollution accidents. Similarly, Ragothaman and Carr (2008) examine the impact of environmental disclosure on the market valuation of firms. They find that reporting waste discharges significantly reduces a firm's value. Moneva and Cuellar (2009) investigate the Spanish market reaction to financial and nonfinancial environmental information. The study concludes that the market values financial (but not nonfinancial) environmental information.

Murray et al. (2006) do not observe a direct association between the shares returns of UK's firms and their social and environmental disclosure. However, they document that longitudinal data shows a positive association between returns and disclosure level. Similarly, Dragomir (2010) does not find a linkage between environmental disclosure and firms' financial performance in the European industrial context. In addition, Cormier and Magnan (2007) find that while additional environmental disclosure reduces the earnings' value in the German setting, this relationship has not been found in either France or Canada. In a more recent study, Clarkson et al. (2010) do not document an association between the environmental disclosures of US firms and their share prices' movement.

While numerous studies have examined the impact of environmental disclosure on firms' cost of equity capital and market value, few studies have investigated the stock market effect of carbon disclosure. Beatty and Shimshack (2010) find that the US-based (NYSE & NASDAQ) stock markets react to the announcement of climate change ratings. Recently, Gans and Hintermann (2011) find that the announcement of voluntarily participation in the Chicago Climate Exchange (CCX) has no impact on excess returns. Griffin, Lont and Sun (2011) observe a negative association between the disclosure of GHG emissions and firms' stock price in the North American context. This negative link is more prominent for carbon-intensive firms.

Given the theoretical and empirical consensus concerning the inverse association between environmental disclosure quality and the cost of equity, this study predicts a negative relationship between carbon disclosure and ex-ante cost of equity capital. This study conjectures that disseminating transparent information about carbon emissions and relevant climate change information reduces information asymmetry problems and increases firms' share liquidity. In addition, revealing such information decreases the costs that investors bear to have this information. This prediction is stated in the following hypothesis:

H2a - There is a negative relationship between the quality of carbon disclosure and the ex-ante cost of equity capital.

Furthermore, LLV's (2007) model and Richardson, Welker and Hutchinson's (1999) argument about impact of environmental and social responsibility disclosure on firms' market value can be applied to carbon emissions and climate change

disclosure. The cost savings that result from the reduction in cost of equity capital increase as a result of disclosing better quality of information relevant to carbon emissions and climate change–associated risk. This process improves a firm's profitability, which in turn enhances a firm's ability to invest its residual profits in new carbon reduction technologies and in initiatives to tackle climate change–associated risks. These efforts are predicted to raise a firm's share price, which leads to a rise of the firm's market value. The previous suggestions are stated in the following hypotheses:

H2b - There is a positive relationship between the quality of carbon disclosure and firm market value.

Clarkson et al. (2010) argue that the analysis of the relationship between environmental disclosure and the cost of equity capital cannot be adequately addressed without also considering environmental performance. This claim stems from the concept that the firms' risk, as assessed by investors, is represented by their environmental performance rather than their environmental disclosures per se (Clarkson et al. 2010). The next section brings the environmental performance measure relevant to this research, carbon risk management, into hypotheses development and commences with an overview of the relationship between carbon risk management and stock market indicators.

2.5 Relationship between carbon risk management and stock market indicators

The potential impact of environmental performance on firms' economic prosperity is a contentious issue. Two terms have been used in these debates: 'win-win' and 'pays

to be green' (Ambec & Lanoie 2008; Clarkson et al. 2011; Feldman, Soyka & Ameer 1997; Hart & Ahuja 1996). The proponents of the win-win concept claim that more stringent environmental regulations benefit micro and macro economies by increasing the competition between firms, and that this results in more innovations, productivity, and consequently profitability (Ambec & Lanoie 2008; Clarkson et al. 2011; Hart & Ahuja 1996; King & Lenox 2002; Porter & Linde 1995b, 1995a). In a sense, by adopting good environmental strategies, a firm can gain economic and social benefits while concurrently protecting the environment.

The counter argument, however, is that the costs of green strategies are quite high for the economy (Palmer, Oates & Portney 1995), and investors perceive these costs as incremental costs that may erode firms' profitability (Cazavan-Jeny & Jeanjean 2006; Hassel, Nilsson & Nyquist 2005). Thus, the nature of the linkage between environmental performance and economic indicators, such as cost of capital and market value, is still under debate. Discussion about the nature of this linkage is based on two approaches: the cost approach and the risk approach.

2.5.1 Theoretical background for the relationship between carbon risk management and stock market indicators

Two dominant approaches have been employed in prior research to explain the economic consequences of environmental performance practices. These are: the cost approach and the risk approach. Thus, the current research employs these two approaches to explain the association between stock market indicators and adopting carbon risk management practices.

2.5.1.1 The cost approach

The cost approach is controversial because incremental environmental costs can be perceived from two different points of view (Dowell, Hart & Yeung 2000; Feldman, Soyka & Ameer 1997; Hassel, Nilsson & Nyquist 2005). The fundamental point of disagreement here pertains to the costs associated with environmental initiatives. These costs can be perceived as investment expenditures that enhance competitiveness and profitability (Porter & Linde 1995a). Proactive firms that improve their environmental management by considering new business requirements, such as new environmental regulations, benefit from cost savings, which increases their profitability and share price. This, in turn, leads to protecting the environment and improving the relationship between a firm and its stakeholders. Cora (2007, p. 68) argues, 'One of the key benefits associated with environmental management systems is their focus on pollution prevention and waste minimization, which can create significant cost savings that lead to improved financial gain (both short-term and long-term).' Therefore, a positive relationship between environmental and financial performance is assumed.

However, the opponents of the previous claim argue that the costs resulting from engaging in green endeavours usually exceed the savings, which results in a waste of firms' resources and decreasing profitability (Chen & Metcalf 1980; Jaggi & Freedman 1992; Wagner et al. 2002). As a result, some investors perceive environmental expenditures as incremental costs that reduce earnings and decrease firms' value (Hassel, Nilsson & Nyquist 2005). This claim is consistent with the argument that the stock market values research and development (R&D) expenditures, regardless of whether these expenditures are financial or

environmental (Booth et al. 2006; Clarkson, Li & Richardson 2004). Therefore, a negative relationship between environmental performance and market value is predicted.

The above discussion can be applied to explain the relationship between carbon risk management and ex-ante cost of equity capital. Firms that have invested a large amount of money in improving their carbon risk management practices can benefit from this expenditure in two ways. First, they can enhance their cash flow through selling the carbon permits they earned from carbon reduction schemes (Laurikka & Springer 2003). Second, these firms can enhance their profits by benefiting from their good reputation through attracting more investors and consumers and by benefiting from tax savings that result from investing in lower carbon technologies (CERES 2003). The reduction in the cost of equity capital and improvement in future cash flows is reflected in increasing market value.

2.5.1.2 The risk approach

The risk approach stems from finance theory. This theory asserts that equity investors incorporate risk components into their investment decisions (Modigliani & Merton 1958; Myers 1984). Risk components are firms' specific risk and market risk (or systemic risk, which is often referred to as *beta*). While investors could mitigate a firm's specific risk by diversifying their portfolio, they require a particular rate of return based on a firm's exposure to systemic risk. Based on the Ohlson's (1995) valuation model, there are three determinants of a firm's market value: book value, abnormal earnings, and non-accounting information relevant to a firm's environmental performance (Hassel, Nilsson & Nyquist 2005).

The argument so far is consistent with Bansal and Clelland's (2004) claim that shareholders perceive poor environmental performers as risky firms and impose a risk premium to invest in these firms. In addition, Feldman, Soyka, and Ameer (1997) build a conceptual framework that explains the mechanism of the relationship between environmental management and financial performance. They argue that firms with a good environmental management record signal this record to the stock market to reduce environmental risk. This process, in turn, reduces a firm's cost of equity capital and raises market value. Thus, investors may consider polluting firms as risky firms, and consequently may decide to exclude these firms from their portfolios or impose high rates on their investments (Heinkel, Kraus & Zechner 2001; Ragothaman & Carr 2008; Semenova & Hassel 2008).

The preceding discussion can be used to investigate the relationship between carbon risk management and the cost of equity capital. Carbon emissions and anticipated carbon reduction regulations represent systemic risk, which applies directly or indirectly to all firms in the market. This claim parallels Hughes's (2000) findings that utility firms targeted by the 1990 Clean Air Act Amendments law (a sulphur dioxide reduction law) experienced a 16 per cent reduction in their share prices. Thus, the required rate of returns imposed by finance providers depend to some extent on the carbon risk involved in the investment. These rates consequently have the potential to affect abnormal earnings. That is, the higher the investment risk involved, the higher the rate on investment required.

Overall, the previous discussion about cost and risk approaches demonstrates that capital market participants consider environmental performance in their investment

decision process. However, the main point of disagreement is whether those participants evaluate environmental performance practices positively or negatively. The premises of these two approaches have been used by various scholars to support their studies, which have reached mixed results.

2.5.2 Prior research on the relationship between carbon risk management and the ex-ante cost of equity capital and market value

The question 'Does it pay to be green?' has led to debate about the financial consequences of adopting new environmental strategies and practices (Ambec & Lanoie 2008; Clarkson et al. 2011; Hart & Ahuja 1996; King & Lenox 2001). To answer this question, several studies have examined the impact of environmental performance practices on the ex-ante cost of equity capital and firms' market value.

Regarding the impact of environmental performance on the cost of equity capital, the early studies of Spicer (1978) and Mahapatra (1984) find that investors include pollution control practices (as a determinant of systemic risk) in their investment decision process. Firms with good pollution control records have lower non-diversified risk and, in turn, exhibit higher profitability and market value (Mahapatra 1984; Spicer 1978). In addition, Feldman, Soyka, and Ameer (1997) apply their framework to 300 US firms and find that firms with good environmental management reduce their market risk and show an increase in stock price of about 5 per cent.

Recently, Halkos and Sepetis (2007) find that Greek firms experience a reduction in systematic risk as a result of their improved environmental risk management and

performance. Sharfman and Fernando (2008) investigate the impact of adopting environmental risk strategies on the cost of debt and equity capital for 267 US firms. Related to the cost of equity capital, they assert that embracing good risk strategies helps firms lower the cost of equity capital by reducing systemic risk. Likewise, Connors and Sliva-Gao (2009) test the impact of environmental performance as measured by chemical emissions on the cost of equity capital. This study was conducted on firms from two emissions-intensive industries: the chemical industry and electric utility industry. Connors and Sliva-Gao (2009) document a positive relationship between emissions levels and the cost of equity capital. Recently, El Ghoul et al. (2011) document that US firms with better corporate social responsibility records are able to obtain cost-effective equity finance.

Overall, the majority of studies conducted on the linkage between environmental performance and risk management and the cost of equity capital yield consistent results. That is, better environmental performance practices are inversely associated with a firm's cost of equity capital. However, at the time of writing this thesis, few other studies have examined comprehensively the relationship between carbon risk management and the ex-ante cost of equity capital.

In regard to the relationship between environmental performance and market value, some studies that investigate the influence of adopting proactive strategies to decrease pollution find a positive relationship. Firms with superior environmental performance experience a higher market value (Clarkson et al. 2011; King & Lenox 2001; Konar & Cohen 2001; Simpson & Kohers 2002; Wahba 2008). Lorraine, Collison, and Power (2004) examine the extent of UK's stock market response to

good and bad news. They conclude that the stock market responds to this news, especially news regarding fines resulting from poor environmental performance. Gupta and Goldar (2005) examine whether India's stock market responds to firms' environmental performance ratings announcements. A positive correlation is found between abnormal returns to a firm's stock and the level of its environmental performance. Al-Tuwaijri, Christensen, and Hughes (2004) find a positive relationship exists between environmental performance and economic performance. The authors attribute this result to investors' preference for the equities of environmentally responsible firms.

Contrary to the previous studies, some other studies have either observed a negative relationship or no effect of environmental performance on firms' market value. Hassel, Nilsson, and Nyquist (2005) find that, taking into account the small sample size and short period of their study, there is a negative relationship between environmental performance and a firm's value. Investors do not reward firms for environmental efforts in the short term (Hassel, Nilsson & Nyquist 2005). In addition, Jacobs, Singhal, and Subramanian (2010) investigate the market reaction to the announcements of two categories of environmental performance: corporate engagement with environmental initiatives and the announcement of environmental awards and certificates. Their study concludes that the stock market is selective and does not consistently react to these announcements. Further, Dragomir (2010) does not find a linkage between environmental performance and firms' financial performance in the European industrial context. Similarly, Moneva and Ortas (2008) find that EU firms do not reap any financial benefits as a result of their sustainability performance.

In summary, previous research that has attempted to investigate the relationship between environmental performance and firm value has provided conflicting results. This can be attributed to several factors including sample size, time period, and differences in measuring environmental performance and firm value (Elsayed & Paton 2005; King & Lenox 2001; Konar & Cohen 2001; Wagner, Schaltegger & Wehrmeyer 2001). While a plethora of studies have examined the relationship between social and environmental performance and firms' value, limited research has been conducted based on carbon emissions and climate change related performance.

Few studies have investigated the impact of undertaking carbon and climate change activities on firms' market value. In USA, Beatty and Shimshack (2010) find that the US-based (NYSE & NASDAQ) stock markets penalise firms with poor climate ratings, but do not reward firms with high climate ratings. Similarly, Gans and Hintermann's (2011) observe that participating in the Chicago Climate Exchange (CCX) has no impact on excess returns. In addition, they find that these returns decrease after the change of CCX carbon prices.

In other settings, Saka and Oshika (2010) examine the impact of carbon emissions and participation in emissions trading on Japanese firms' market value. They illustrate that while the emissions volume is negatively associated with the market value, participation in emissions trading has non-significant positive association with market value. This study concludes that investors consider carbon related risks in their decision-making. Chapple, Clarkson and Gold (2011) find that Australian

investors deduct about 7 per cent to 10 per cent of high polluting firms' share price as a result of a proposed 2008 Australian carbon reduction scheme.

The preceding theoretical and empirical logic are applied in this study to investigate the relationship between carbon risk management and the ex-ante cost of equity capital and market value. First, it is reasonable to assume that firms are experiencing more pressure to deal with the progressive rise in awareness about carbon emissions and climate change associated risks. Firms that espouse new strategies and orient themselves toward reducing their carbon emissions and tackling climate change risks gain substantial reductions in their systemic risk. This in turn decreases the premium that investors require to invest in these firms. Therefore, this research predicts a negative relationship between carbon risk management and ex-ante cost of equity capital. This prediction is stated in the following hypothesis:

H3a- There is a negative relationship between carbon risk management and ex-ante cost of equity capital.

Second, firms that position themselves well to operate in increasingly stringent carbon markets may benefit from their efforts in several ways. These firms can trade their carbon allowances as a result of their superior carbon performance. This enhances their reputation, which in turn could increase sales of their products. In addition, superior carbon performers are less exposed to litigation costs that may result from not complying with new carbon regulations. These benefits and the reduction in the cost of equity capital increase future cash flows and consequently maximise the net present value of these firms.

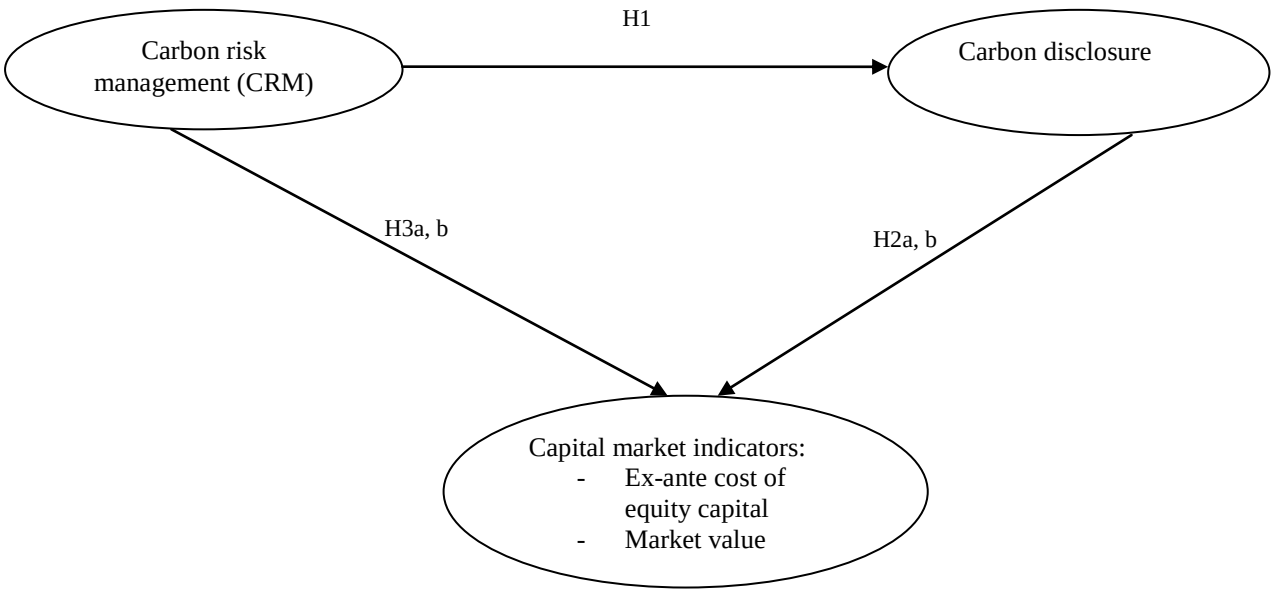
However, although adopting good carbon risk strategies is sometimes costly, the long-run benefits of these costs and appropriate investment valuations are value adding (Feldman, Soyka & Ameer 1997). Thus, these strategies may enhance firms' stock price. Ultimately, a positive relationship between good carbon risk management practices and a firm's market value is expected, as stated in the following hypothesis:

H3b - There is a positive relationship between carbon risk management and firm market value.

2.6 The conceptual model

Before concluding this chapter, it is important to summarize the previous sections within an integrated conceptual framework. Figure 2.2 depicts the relationships between this study's constructs and illustrates the hypotheses developed in the previous sections.

Figure 2.2 Relationship between carbon risk management, carbon disclosure, and the ex-ante cost of equity capital and market value



2.7 Chapter summary

This chapter outlines the theories that provide an appropriate underpinning for this study's hypotheses. First, two common sets of theories, socio-political and economic-based disclosure theories, are reviewed in order to examine the relationship between carbon risk management and carbon disclosure. While these two sets of theories aim to explain voluntary disclosure incentives, they embrace different perspectives which, in turn, are reflected in the different predictions emanating from them (Clarkson, Overell & Chapple 2011). In addition, a comprehensive review of prior research is undertaken. The combination of these theoretical backgrounds and empirical results are employed to derive a hypothesis about the association between carbon risk management and disclosure.

With regard to the economic effects of environmental disclosure, there is no agreement on the mechanism explaining the link between environmental disclosure and economic performance. Thus, prior research yields inconclusive results in this area. In this vein, Lambert, Leuz, and Verrecchia (2007) and Richardson, Welker and Hutchinson (1999) develop models that could be used to elucidate the direction and extent of the linkage between environmental disclosure quality and capital market effects. These models and relevant literature are reviewed to predict the potential economic benefits of disseminating transparent carbon emissions and climate change related information.

Finally, the cost and risk approaches predict the existence of a relationship between environmental performance and capital market indicators. These approaches and the relevant literature are reviewed to conjecture a relationship between carbon risk

management and capital market performance. The next chapter explains the research methods used to test the hypotheses developed in the current chapter.

CHAPTER 3 RESEARCH METHODS

3.1 Introduction

This chapter outlines the methods used in this study to test the hypotheses formulated in chapter 2, and is organised as follows: Section 3.2 explains the research sample selection process. Section 3.3 identifies the data sources used. Section 3.4 explains the measures used to calculate the dependent and independent variables. Section 3.5 describes the control variables included in tests to control for potential impacts on dependent and independent variables. Section 3.6 outlines the tests used in this research to test its hypotheses. Finally, section 3.7 summarises the chapter.

3.2 Sample selection

The targeted sample of this study are the largest 500 firms worldwide (hereafter G500). These 500 firms are chosen from the FTSE Global Equity Index Series as of June 2009. The selection of 2009 as the sample period for this research is made as it considers a recent year that has available information from the Carbon Disclosure Project (CDP) database and sustainability reports at the time of data collection. These firms were ranked as the biggest in terms of sales, and have a market capitalisation of US $15.5 trillion.

The first reason for choosing the G500 is that these firms are included in the CDP questionnaire in 2009. CDP is a non-profit organisation, which acts on behalf of 534 institutional investors worldwide. It launched in 2000, and since 2003 has started requesting information relevant to climate change from more than 3,700 firms across

the world. This information includes the identification of carbon and climate change–associated risks and opportunities; the actions taken by firms to manage and adapt to these risks and opportunities; carbon and greenhouse gas emissions, actions, and strategies that have been and are taken to mitigate carbon emissions; and finally governance strategies adopted by firms to deal with carbon and climate change matters. Hence, the CDP's database is the most comprehensive database of carbon and climate change–related information that is publicly available (Griffin, Lont & Sun 2011; Matsumura, Prakash & Vera-Muñoz 2011). Because of these advantages and their relevancy to this study's objectives, CDP's reports and responses are chosen as an alternative source for carbon risk management and disclosure data.

Second, the biggest firms have been chosen because of their impact on the economies where they perform their operations (Jose & Lee 2007). Third, some previous studies have attributed the mixed results of prior research to shortcomings such as sample size and the context where these studies were conducted (Clarkson et al. 2008; Patten 2002). Therefore, choosing a big sample that includes a wide range of industries and countries overcomes these shortcomings. While it is clear that this sample is biased toward the largest firms, this limitation does not constitute a big problem as these firms are targeted for valid reasons and are included in the CDP questionnaire sample. In addition, it has been argued that disclosure (especially environmental disclosure) practices in big firms are richer than for small and medium firms (Deegan & Gordon 1996; Patten 1991).

To be included in the empirical tests, firms must fulfil the following criteria:

1- Have completed and published their response to CDP's questionnaire.

2- Have an accessible English-language website.

3- Have complete financial information available in the OSIRIS database.

All firms that completed the CDP 2009 questionnaire and allowed their responses to be published on the CDP website are chosen since this study is built on the assumption that all carbon information should be voluntarily and publicly available. Additionally, all information should be published in English language since the researcher is unable to translate languages other than Arabic. Finally, all financial information should be available on the OSIRIS database to calculate the stock market indicators, and because it is the only database available for the researcher. Applying previous criteria left a final sample of 288 firms for tests of this study's hypotheses (see Table 3.1).

Table 3.1 Sample selection process

Largest 500 firms in the FTSE Global Equity Index Series (G500)	**500**
Less firms that:	
Declined to participate in CDP	13
Did not respond to CDP	49
Provided some information to CDP but did not complete the questionnaire	19
Refused publication of their information	67
Response with no GHGs information (no intensity measure)	17
Answered late (no scores)	8
Answered in a language other than English	8
Acquired	22
Questionnaire completed and published by CDP	**297**
Negative revenue	1
Share prices and earnings forecasts not available	8
Final Sample for analysis	**288**

Two hundred and three firms are excluded from the G500 because of their failure to complete the CDP questionnaire or because of an inappropriate response (see Table

3.1). One further firm is omitted because it has negative revenue, which makes the calculation of its carbon intensity unfeasible (see appendix 1 for more details about the calculation of carbon intensity). Finally, eight more firms are eliminated because they do not have available share price and earnings forecasts data to calculate the ex-ante cost of equity capital.

Sample firms have been classified based on their sector affiliation as defined by the Global Industry Standard Classification (GISC) (see Table 3.2). This classification has been developed in cooperation with Morgan Stanley Capital International (MSCI) and Standard & Poor's (S&P). These two independent organisations are considered leading investment advisors worldwide. Based on the GISC methodology, G500 firms have been assigned to sectors based on their principal activities as determined by revenues. In addition to sector affiliation, for the purpose of this research, these firms have been divided into two groups based on whether they are included in the final sample.

As can be seen from Table 3.2 (Panel A), the distribution of G500 into sectors is quite convergent, with the exception of the financials sector. The financials sector represents about 22 per cent of the G500, whereas other sectors range from about 7 per cent to 11 per cent. In addition, the proportions of firms in each sector group within the reduced sample are quite similar to those of the full sample. In addition, Panel B of Table 3.2 shows that North America's firms represent the largest group in the sample, accounting for 45.5 per cent. The second and third groups are EU and Asia & pacific with a proportion of 27.1 per cent and 16 per cent respectively.

Table 3.2 Breakdown of G500 by sector and region affiliation as at June 2009

	Full sample (500)		Excluded for several reasons(see Table 3.1)		Reduced sample	
Panel A: Distribution of sample firms between sectors						
Sector	No	Percentage	No	Percentage	No	Percentage
Industrials	54	10.8%	30	14.2%	24	8.3%
Consumer discretionary	37	7.4%	16	7.5%	21	7.3%
Consumer staples	51	10.2%	20	9.4%	31	10.8%
Energy	54	10.8%	24	11.3%	30	10.4%
Financials	109	21.8%	53	25.0%	56	19.5%
Materials	35	7.0%	9	4.3%	26	9.0%
Telecommunications	33	6.6%	14	6.6%	19	6.6%
Utilities	44	8.8%	12	5.7%	32	11.1%
Health care	43	8.6%	20	9.4%	23	8.0%
Information technology	40	8.00%	14	6.6%	26	9.0%
Total	**500**	**100%**	**212**	**100%**	**288**	**100%**
Panel B: Distribution of sample firms between regions						
North America	220	44%	89	42%	131	45.5%
EU	112	22%	34	16%	78	27.1%
UK	33	7%	6	3%	27	9.4%
Asia & Pacific	115	23%	69	32%	46	16%
Others	20	4%	14	7%	6	2%
Total	**500**	**100%**	**212**	**100%**	**288**	**100%**

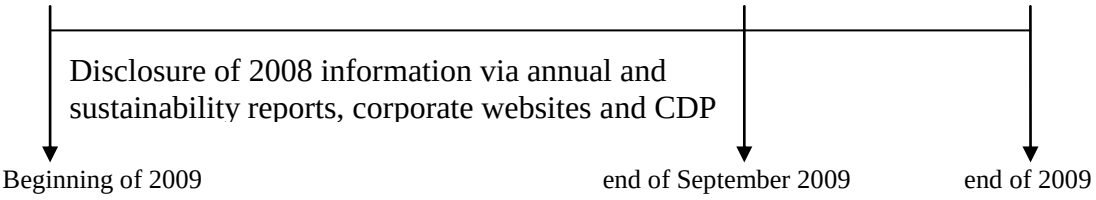
The reason behind using only one year to conduct this research is the time restrictions. 288 firms' reports were manually content analysed to develop the carbon disclosure and carbon risk management scores (see variables measurement section for more details). These reports are the annual and sustainability reports, corporate website, and CDP questionnaires for each sample firm. In addition, choosing one year is, to some extent, consistent with the claim that disclosure practices are constant and do not significantly change over time, regardless of whether disclosure type is financial (Botosan 1997) or environmental (Aerts, Cormier & Magnan 2006; Cormier, Magnan & Van Velthoven 2005).

Data relevant to carbon risk management and carbon disclosure relates to the financial year 2008. That is, while this research uses the CDP 2009 questionnaire, all information included in responses to this questionnaire belongs to the 2008 financial

year. Thus, annual and sustainability reports relevant to the 2008 financial year, which were made publicly available in the 2009 year are analysed. In addition, corporate websites are accessed in 2010 by tracing any archival information related to the 2008 financial year in HTML and PDF format.

Finally, Consistent with prior research, a time lag of at least three months is considered for capital market data. Thus, the ex-ante cost of equity capital and market value proxies are estimated at the end of the 2009 financial year. This consideration is accomplished since the CDP 2009 questionnaires were made publicly available by the end of September 2009. In addition, annual and sustainability reports for the 2008 financial year were made available during 2009 (normally by the end of March) or earlier. The releasing of carbon information and the consumption of this information in stock markets are depicted in the following time line.

Figure 3.1 Time line of this study's events



3.3 Data sources

Data relevant to carbon risk management and disclosure are obtained from the CDP database (CORE) and sustainability reports. This is because carbon disclosure is measured using two different approaches. The CORE database is a tool that transfers all information provided in response to the CDP questionnaire to Microsoft excel

worksheets. This process makes access to particular carbon information faster and easier.

Data for capital market indicators and control variables are collected from the OSIRIS database. This database is one of the Bureau van Dijk Electronic Publishing (BvDEP) products. It covers more than 45,000 listed and unlisted firms across the world (BvDEP 2006). Financial information available in OSIRIS includes historical data, such as balance sheets and income statements, annual stock and security prices, financial ratios and forecasts, and analysts' estimations.

3.4 Measurement of dependent and independent variables

This study has three constructs. These are carbon risk management, carbon disclosure, and stock market indicators. Carbon disclosure is proxied by two alternative indices. These are the CDP 2009 index as awarded by CDP experts based on CDP responses, and a similar index awarded by the researcher based on sustainability reports. The stock market indicators comprise ex-ante cost of equity capital and market value.

3.4.1 Carbon disclosure indices

Several methods have been used in prior research to measure disclosure level. These methods include self-constructed indices and indices generated by independent organisations. These two methods use content analysis to quantify qualitative information. Content analysis is performed to analyse the firms' sustainability reports. Abbott and Monsen (1979, p. 504) define content analysis as 'a technique

for gathering data that consists of codifying qualitative information in anecdotal and literary form into categories in order to derive quantitative scales of varying levels of complexity'. The main objective of content analysis is the reliable coding and quantifying of narrative information (Krippendorff 2004). This type of research design has been widely employed for collecting data and evidence relevant to financial, social, and environmental performance and disclosure practices (Guthrie & Abeysekera 2006; Holder-Webb et al. 2009; Milne & Adler 1999; Parker 2005). According to Parker (2005), 19 per cent of social and environmental research conducted from 1988 to 2003 has employed content analysis.

Two dominant approaches to content analysis have been used in prior research to assess and evaluate disclosure practices. These two methods are volumetric and index approaches (Vourvachis 2007). The volumetric approach is a method that measures the volume of disclosure in a particular avenue by counting words, sentences, or pages related to a specific topic (Vourvachis 2007). The first step in this method is defining the documents that are to be analysed and the units of analysis. Annual reports are used extensively as a source of information in prior research. The dependency on this source is justified as (a) these reports are reliable documents that communicate a firm's activities, and (b) these documents are distributed widely among a large, diverse range of stakeholders (Deegan & Rankin 1997; Unerman 2000).

However, relying on annual reports has been criticised as they do not provide a thorough picture of a firm's operations (Roberts 1991; Unerman 2000; Zeghal & Ahmed 1990). After deciding which documents to analyse, units of analysis must be

properly identified. Units that were employed in the past have ranged from words, sentences, and lines to paragraphs and pages. Although this method is prevalent in social and environmental research, it is vulnerable to several drawbacks. Counting individual words, for example, has no meaning and does not provide a sound basis for coding environmental disclosures (Milne & Adler 1999). Furthermore, merely counting sentences is subject to grammatical problems, in which the same message may be conveyed in different sentences (Unerman 2000). Moreover, considering the number of pages as a unit of analysis may ignore the amount of information included on each page because of differences in font and page size (Milne & Adler 1999).

The index approach, on the other hand, seeks to assess the quality of disclosure by interpreting narratives in a particular manner (Beattie, McInnes & Fearnley 2004; Beck, Campbell & Shrives 2010; Cormier, Magnan & Van Velthoven 2005). Two schemes have been used in prior studies to quantify a firm's disclosures. These are binary and weighting systems. In the binary approach, a researcher resorts to scoring disclosure based on the presence or absence of particular information in the text being analysed. In this method, a researcher assigns one point for the presence of certain information, and zero otherwise (Clarkson et al. 2008; Da Silva Monteiro & Aibar-Guzmán 2010; Freedman & Jaggi 2005). While this process has the advantage of being an easy proxy for disclosure, especially in big sample research, it ignores the quality and materiality of disclosure. The weighting method avoids this weakness by assigning scores based on the quality of information (Wiseman 1982) and the importance and materiality of specific information to particular users.

According to this method, a scale of points is assigned to predetermined categories. The highest score is given to categories that contain quantitative disclosures. Wiseman (1982), for example, develops an index based on six environmental categories. These categories take a value of 3 if the information is provided in a quantitative manner, a value of 2 if it is provided in a specific manner relevant to the firm, a value of 1 if it is general rather than specific, and 0 if the information is not provided. However, Morhardt (2001) claims that applying one scale to all categories and for different firms is questionable. Therefore, other studies have developed a more precise method that captures the quality of disclosure by applying different scales to different categories (Clarkson et al. 2008; van Staden & Hooks 2007). This new approach is employed in the Carbon Disclosure Leaders Index 2009 (CDLI 2009). The following two sections describe how CDLI 2009 methodology avoids these shortcomings to capture the disclosure quality.

3.4.1.1 Carbon disclosure index (CDIS1)

This research uses the Carbon Disclosure Leaders Index 2009 (CDLI) score as the first proxy for carbon disclosure (CDIS1). Firms are scored in this index based on the CDP 2009 scoring methodology (see appendix 1 for detailed information). These scores are available on the CDP website (CDP 2009). It should be clarified that while this index is labelled as CDP 2009, all information that is provided in responses to CDP's 2009 questionnaire relates to the 2008 financial year.

The decision to use this methodology has been made for several reasons. First, there is congruency between the objectives and outcomes of this scoring system and the objectives of this research. That is, this methodology captures what this study

intends to capture. All climate change and carbon emissions information which are anticipated as being important to investors are categorised in this methodology (see Table 3.3). Second, as discussed above, this methodology uses different approaches to capture the quality of carbon disclosure rather than its quantity. Thus, it fits with the objectives of this study given that one of this study's constructs is the carbon disclosure quality. Third, choosing this methodology helps in extending the sample to the whole G500 since it considers all different industries, which in turn, increases the research's external validity. External validity allows the results to be generalised to other contexts (Leedy & Ormrod 2005). Fourth, this methodology was constructed by experts and advisors from the CDP organisation and PricewaterhouseCoopers (PwC), which provides professional credibility.

Relevant to scoring-accuracy purposes, firms were scored by two independent reviewers from CDP and PwC, and a scoring process was also used by a third, independent reviewer in the case of a difference between the scores of the first two reviewers. Fourth, using this methodology decreases the time that would be consumed in analysing the CDP reports and sustainability reports if the researcher needed to perform this scoring. Finally, the other advantage of the CDLI methodology is that it focuses on specific information relevant to carbon emissions and climate change rather than merely counting the amount of information (word, lines, or pages). That is, this methodology considers the quality of disclosure rather than just the quantity. In this regard, the CDLI has been constructed using a mix of binary value and weighting approaches.

With the binary value method, firms are given one point for answering particular questions, regardless of whether their answer is Yes or No. With the weighting method, firms are scored based on different scales, and the scores assigned to each scale are different as well. These scales consider carbon information quality in terms of the extent of detail and relevancy to the firm, provision of examples or case studies, and the inclusion of quantitative or financial information. Further, the materiality or the importance of particular information is considered by assigning more points to certain information (e.g., GHG emissions data receives 3 points).

According to the CDLI, experts from CDP and PwC rank firms by awarding them scores reflective of the quality of their disclosure. Thus, the high scores given to firms refer to a high quality of carbon disclosure. Scores are given for the following five categories: risk and opportunities, emissions accounting, verification and trading, performance, and finally governance. Scores range from 120 to 176 points depending on the applicability of the questions and responses to conditional questions.

Table 3.3 Distribution of scores among categories

Category	**Scores available**			
	Stand-alone questions	**Lead questions**	**Conditional questions (Yes)**	**Conditional questions (No)**
Risks and Opportunities	0	6	30	18
Emissions Accounting	34	10	7	4
Verification and Trading	7	9	23	1
Performance	14	10	12	1
Governance	-	4	10	2
Total	55	39	82	26

The applicability and conditional questions are considered to be advantages of CDLI. This methodology considers the applicability of particular questions to particular firms, and firms will not be penalised because some questions do not apply to them. For example, if a firm has no direct emissions (e.g., financial firms), it does not need to respond to certain questions and ultimately will not be penalised for no response in the scoring system. The scores of inapplicable questions or the scores for associated 'conditional no' questions are deducted from both the numerator and denominator when calculating a firm's score. For the purpose of analysis and comparison, the actual scores achieved are normalised against 100 as follows:

Final score = (score achieved / score available) *100

This scoring methodology is also employed for the scored proxy for carbon disclosure, which is based on sustainability reports.

3.4.1.2 Carbon disclosure index (CDIS2)

In attempting to cover all voluntary disclosure channels, this study evaluates all information that could be disseminated via several communication channels. This is due to the differences in information released via different reporting channels (De Villiers & van Staden 2011; Tran, Okafor & Herremans 2010). Thus, the second proxy for carbon disclosure (CDIS2) is estimated based on sustainability reports[4]. Content analysis was undertaken by the researcher to quantify all carbon relevant information in these reports.

[4] Recall that "sustainability reports" term in this study includes annual reports, stand-alone sustainability reports as well as corporate websites.

Consistent with CDP 2009 information, all information released via 2008 sustainability reports are analysed using the CDP 2009 scoring methodology (see preceding section and appendix 1 for more details about this methodology). Two important issues are considered when undertaking this procedure. First, any replicated information that was provided in two or three communication channels was counted only once. Second, for the purpose of reliability, the researcher had some training (as suggested by Milne and Adler (1999)) before analysing the sustainability reports. This training was accomplished by practice in analysing the firms' CDP responses and comparing the researcher's scores with those of CDP to ensure a consistent coding technique was achieved. In addition to the scoring methodology used for the two carbon disclosure proxies outlined in this section, a different scoring methodology is required to estimate carbon risk management scores for each sample firm.

3.4.2 Carbon risk management measure (CRM)

This study uses the CDP's performance score methodology to measure carbon risk management (CRM). This scoring system has been chosen due to its relevance to the carbon risk management concept, which has been developed in this study (see figure 1.1). Each of the aspects of this construct: carbon intensity, potential risks, and carbon management is considered in the CDP performance scoring system.

Carbon intensity analysis is parallel to the emissions and emissions trading category. Potential risks and opportunities refer to potential risks and opportunities relevant to carbon emissions and climate change. These risk issues are included under category 1 of the CDP method in which firms are assessed based on their ability to manage, adapt to, or minimise these risks. These risks and opportunities relate the 'potential

risks' aspect of the carbon risk management construct. Furthermore, the remaining three categories in the CDP method accord with the remaining aspects that are identified in this study and can be coined under the term *carbon management*. Hence, the CRM scores are assigned by the researcher based on the CDP performance scoring system. This process is used since the CDP's performance scores are proprietary, and therefore were not available to the researcher. Data relevant to the carbon risk management scores is obtained from the CORE database.

According to the CDP performance methodology, firms are awarded points based on the *actions* they have taken regarding carbon emissions and climate change. A legitimate question that can be raised here is whether this methodology may unintentionally measure disclosure level and performance. This problem is minimised since the CDP performance methodology measures and assesses performance based on material actions that firms have taken to manage carbon emissions and climate change issues. Some firms, for instance, were given points as a result of their recognition of the risks and opportunities associated with climate change. However, these firms scored zero in regard to their response to dealing with these risks and opportunities.

Table 3.4 Distribution of scores for actions taken

Actions	Available scores
Risks and Opportunities	6
Emissions Accounting	9
Verification and Trading	3
Performance	13
Governance	6
Total	**37**

There is a high degree of consistency between this methodology and methodologies that have been used in prior research. Most previous research has focused on particular aspects of firm performance regarding the environment. Ilinitch, Soderstrom, and Thomas (1998) develop a matrix that contains four dimensions of environmental performance: process, outcome, internal, and external components. Sharfman and Fernando (2008) and Al-Tuwaijri, Christensen, and Hughes (2004) assess firms' environmental performance by using quantitative and qualitative measures. The quantitative measurement they use is the ratio of total emissions (or total toxic) treated or recycled to total emissions generated. For qualitative measurement, the firms were ranked based on their commitment to certain principles, such as those of the Coalition for Environmentally Responsible Economics (CERES) (Al-Tuwaijri, Christensen & Hughes 2004), or they were ranked based on the strength and concern they demonstrated such as the KLD's ratings (Sharfman & Fernando 2008).

Similar to prior research, the CDP methodology uses quantitative and qualitative approaches in order to assess a firm's carbon risk management. For the quantitative approach, firms were scored in terms of their emissions intensity by dividing their total emissions (as disclosed by the firm) by their turnover. It should be noted here that the turnover figures have been adopted as disclosed by the firm and have not been adjusted to take into account the base of reporting (whether based on equity share or operational control). This limits the comparability base between firms in terms of their carbon intensity. Given the big variance between sectors in terms of their carbon intensity, firms within each sector are ranked as high, medium, and low emission intensity (for more details see appendix 1, question 16.1). A similar

approach to control for industry differences is used by Clarkson, Li and Richardson (2004) and Clarkson et al. (2008).

For the qualitative assessment, the CDP performance score ranks firms based on several management aspects that are considered good practices. These management aspects are actions that firms have taken to identify, adapt, and manage carbon risks; actions that have been taken to reduce emissions; plans and targets that have been put in place (short- and long-term plans) to mitigate emissions and their associated risks; the accomplishments of previous plans and targets; the investments required and cost savings achieved as a result of reduction activities; the level of responsibility delegated to managers in order to manage emissions and climate change issues; and the level of disclosure and engagement with the community and policy makers on issues relevant to GHG emissions and climate change. These activities are considered aspects of robust carbon management that would enhance shareholders value and provide a climate competitive advantage (Lash & Wellington 2007; PWC 2008). Therefore, a firm that achieves a high score is superior in dealing with carbon emissions and climate change and the associated anticipated risks and opportunities. Finally, for the purpose of analysis and comparison, the actual scores achieved are normalised against 100 as follows:

Final score = (score achieved / score available) *100

After measuring the two constructs of this study which are carbon risk management and disclosure, the next section moves to illustrate the measurement of a third construct which are capital market indicators.

3.4.3 Stock market performance indicators

Two stock market indicators are used in this research as proxies for financial (economic) performance. These are ex-ante cost of equity capital and market value. These measures are chosen since prior research about the effect of environmental performance and disclosure on firms' economic performance focuses widely on these market-based indicators (Clarkson et al. 2010; Connors & Sliva-Gao 2009; Dejean & Martinez 2009; Jacobs, Singhal & Subramanian 2010; Moneva & Cuellar 2009; Plumlee et al. 2010; Plumlee, Brown & Marshall 2008; Richardson & Welker 2001; Sharfman & Fernando 2008). In addition, these measures are expected to reflect the stock market reaction to the carbon risk management disclosure consistent with the objectives of this research. The methods used to calculate these proxies are detailed in the following sections.

3.4.3.1 Cost of equity capital proxy (E (Ke))

Cost of equity capital refers to the required rate of return on investment that is adjusted for the time value of money and risk (Lally 2000). Consistent with this definition, Daske, Gebhardt and klein (2006, p. 4) define it as 'the rate of return investors require for an equity investment in the firm'. Botosan and Plumlee (2005, p. 21) define it as 'the discount rate the market applies to a firm's expected future cash flows to arrive at current stock price'.

It is important to note that all cost of equity capital definitions are based on it being a forward concept because it relies on expectations; where this cost represents the returns that investors expect to earn in the future, evaluated using the present price. However, a wide variety of methods and approaches have been used to estimate cost

of capital in prior research. Several previous analytical and empirical research studies have been conducted in order to find an ideal method to estimate cost of equity capital. To date, no agreement between scholars has been reached in developing a unified approach.

Two dominant methods have been used previously as proxies for estimating the cost of equity capital. These methods are the capital asset pricing model (CAPM) (Sharfman & Fernando 2008) and sub-methods derived from the dividend discount model. The CAPM model has been heavily criticised as it relies on average realised returns as a method to estimate the expected rate of returns (Botosan 1997; Brav, Lehavy & Michaely 2005; Daske, Gebhardt & klein 2006; Gebhardt, Lee & Swaminathan 2001; Goedhart, Koller & Wessels 2002). Botosan (1997, p. 336) states, 'average realized returns provide an extremely noisy measure of cost of equity capital'. Several methods have been derived from the dividend discount model. All of these methods equate the current price with the adjusted expected future cash flows. Therefore, these methods differ from the average realised method in that they rely on analysts' forecasts about future returns (dividends per share) rather than on realised returns.

Botosan and Plumlee (2005) and Botosan, Plumlee, and Wen (2011) investigate several methods in terms of their reliability and accuracy in estimating the E (Ke). They observe that these methods differ in their assumptions about the terminal value. Their investigations test the extent to which each method is able to capture the factors relevant to firm specific risk. These factors are market risk, leverage, information risk, firm size, and growth. They conclude that the Target Price method

(r_{DIV}) and the PEG Ratio method (r_{PEG}) are the most appropriate methods to calculate the E (Ke) because of their relevancy to the firm's risk factors. In attempting to avoid the shortcomings of using individual methods, some scholars espouse an alternative approach. They estimate the E (Ke) by applying several separate methods or averaging two or more methods in order to reduce errors that may be associated with employing single method (Clarkson et al. 2010; Dhaliwal et al. 2011; Plumlee et al. 2010; Plumlee, Brown & Marshall 2008). However, Botosan, Plumlee, and Wen (2011) examine the validity of averaging several approaches to produce a precise metric for E (Ke). They conclude that this procedure does not (in most cases) provide an accurate measure for E (Ke).

Given that r_{PEG} has less data requirements than r_{DIV}, and limited access to capital market data, this study resort to use r_{PEG} as a proxy for ex-ante cost of equity capital. Based on the r_{PEG} method, the E (Ke) is calculated as follows (Easton 2004):

$$r_{PEG} = \sqrt{\frac{eps_2 - eps_1}{P_0}} \quad (1)$$

Where:

r_{PEG} = estimated E (Ke)

eps_2 = two years ahead median forecasted earnings per share

eps_1 = one year ahead median forecasted earnings per share

P_0 = price at time = 0

E (Ke) is estimated at the end of 2009.

However, this method is sometimes not applicable because earnings forecasted in the second year (eps_2) are sometimes less than earnings forecasted in the first year (eps_1) (Botosan & Plumlee 2005). Hence, Botosan and Plumlee (2005) address this shortcoming by using long-run earnings forecasts (eps_5 and eps_4) instead of (eps_2 and

eps₁). They justify this modification as *eps₅* is always higher than *eps₄*. Therefore, for robustness, a second test based on long-run earning forecasts is conducted as follows:

$$r_{PEG} = \sqrt{\frac{eps_4 - eps_3}{P_0}} \quad (2)$$

Four years rather than five years are employed since the OSIRIS database contains earnings forecasts for only four years ahead.

3.4.3.2 Market value proxy (MV)

Several studies have estimated a firm's market value as the market value of common equity per share (Clarkson, Li & Richardson 2004; Filbeck & Gorman 2004; Hassel, Nilsson & Nyquist 2005; Hughes 2000; Johnston, Sefcik & Soderstrom 2008; Matsumura, Prakash & Vera-Muñoz 2011; Moneva & Cuellar 2009; Plumlee et al. 2010; Plumlee, Brown & Marshall 2008). These studies rely on Ohlson's (1995) valuation model. These studies have employed different approaches to mitigate the so-called "scale-effect" in cross-sectional analysis (Barth & Clinch 2009; Easton & Sommers 2003). That is, due to the differences in firms' size, several approaches have been suggested to solve this problem. Ohlson's (1995) model is modified by using different deflators such as shares outstanding, total sales, total assets, and book value (Barth & Clinch 2009; Easton & Sommers 2003; Lara, Grambovas & Walker 2009). However, Barth and Clinch (2009) examine these approaches and find that share-deflated and un-deflated approaches are effective in reducing the scale-effects.

For the purpose of the current study, a pilot analysis based on share-deflated specification is conducted. The results show the existence of heteroscedasticity. This problem may be attributable to the financial data, specifically share price, being drawn from different countries and thereby having different characteristics. For this reason and in line with Clarkson, Li and Richardson (2004) and Kallapur and Kwan (2004), this study chooses to apply the un-deflated Ohlson's (1995) model. That is, market value is estimated as the market value of common equity in US million dollars. Market value was estimated in previous studies three months after the end of the financial year to observe the potential impact of disclosure on firms' market value. As discussed in section 2.3, and consistent with prior research, a time lag of three months is used in this research, thus the market value is estimated at the end of the 2009 financial year.

3.5 Selection and measurement of control variables

Several control variables are incorporated in the hypotheses testing process due to their potential impact on the dependent variables. These variables have been drawn from the literature. The definitions, nature of anticipated effects, and measures of these variables are detailed in the following sections based on their relevancy to the dependent variables.

3.5.1 Carbon disclosure determinants

Several variables have been recognised in prior research as potential driving forces behind some disclosure practices. Given the theoretical support for the relationship between disclosure level and financial performance, several studies include firm

profitability as a variable to control for its potential impact on disclosure. Three indicators have been used to capture profitability: these are return on equity (ROE), return on assets (ROA), and profit margin or return on sales (ROS). While Clarkson et al. (2008) and Freedman and Jaggi (2005) do not find a significant association between the ROA and environmental disclosure, Liu and Anbumozhi (2009) find that ROE is positively associated with environmental disclosure. Conversely, Prado-Lorenzo et al. (2009) observe an inverse relationship between ROE and the amount of GHG information disclosed. For this reason and because ROE is screened more by shareholders and anticipated investors, this research elects ROE as an economic performance proxy. ROE is measured as the ratio of net profit to shareholders' equity.

It is argued in the literature that firms expand their disclosure if they intend to raise their equity or debt capital (Francis, Khurana & Pereira 2005; Frankel, McNichols & Wilson 1995). This ***financing*** approach to disclosure is used to reduce the estimation risk and information asymmetry between managers and potential investors, which, in addition, can result in lowering the cost of new funds (Clarkson et al. 2008). This argument has relevancy to environmental disclosure, where a firm that intends to issue new equity or debt capital is likely to enhance its environmental disclosure to reduce the estimation risk for future investors. Capital raising is proxied by a material increase in shares or debt in 2010. Following Collett and Hrasky (2005), and based on the accounting principle of materiality, the issuance of shares or debt of more than a five per cent is considered to be material. Therefore, a value of 1 is assigned if shares (S-FIN) and/or debt capital (D-FIN) has increased by more than 5 per cent, zero otherwise.

The notion of controlling for ***leverage*** is that firms with high leverage adopt accounting policies that allow them to disclose detailed information about their financial or social performance. This behaviour can be attributed to these firms wanting to avoid agency costs which may be imposed by creditors (Clarkson et al. 2008), or to keep particular stakeholders (investors, creditors) informed in order to avoid debt-covenants' breaches (Freedman & Jaggi 2005). Therefore, firms with high leverage are more likely to provide detailed information about their carbon emissions and climate change–related risks and opportunities. This higher level of disclosure is predicted since these firms (especially firms from carbon-intensive industries) have incentives to reduce uncertainty about the risk of default. **LEV** is measured as total debt to total assets.

Firm's ***size*** has been widely used in the literature to control for its effect on the cost of equity capital and financial and environmental disclosure level. In respect of its relevancy to the cost of equity capital, prior research finds a firm's ***size*** has an inverse impact on the *cost of equity capital* (Botosan 1997; Botosan & Plumlee 2005; Leuz & Verrecchia 2000). This impact is interpreted as large firms being able to provide more information than small firms, which in turn reduces the investors' perceived estimation risk and the rate of return required. In addition, Plumlee, Brown and Marshall (2008) control for firm size when they investigate the link between firms' *market value* and environmental disclosure. They justify it as a control for variation in information quality.

With regard to its relationship with disclosure practices, numerous previous studies control for a firm's size as a key determinant of disclosure level. Two dominant

reasons explain this relationship: large firms have the resources to disseminate detailed information, and these firms are susceptible to a high degree of public scrutiny (Liu & Anbumozhi 2009; Stanny & Ely 2008). In respect of environmental disclosure, most of the literature finds that environmental disclosure level is positively associated with firm size (Clarkson et al. 2008; Cormier, Magnan & Van Velthoven 2005; Freedman & Jaggi 2005; Liu & Anbumozhi 2009; Richardson & Welker 2001; Stanny & Ely 2008). More recently, Prado-Lorenzo et al. (2009) find that a firm's size positively influences its disclosure of GHG emissions information. **SIZE** is estimated as the total sales in US million dollars at the end of 2009.

It has been recognised in the literature that ***firm affiliation*** or industry classification represents a disclosure driver regardless of whether this disclosure is financial, social, or environmental. The assumption behind controlling for industry in this research is that firms belonging to environmentally sensitive sectors tend to disclose more information about their environmental activities because they are subject to strict regulations or because a cost-based perception spurs the disclosure level. Many studies argue that polluting firms divulge large amounts of information in order to lower the cost of equity capital through the reduction of information asymmetry or to avoid potential litigation costs (Al-Tuwaijri, Christensen & Hughes 2004; Cho & Patten 2007; Liu & Anbumozhi 2009; Patten 2002; Richardson & Welker 2001; Stanny & Ely 2008). In addition, firms' response to the climate change phenomenon varies from sector to sector (Dawkins & Fraas 2011; Jeswani, Wehrmeyer & Mulugetta 2008).

For the purposes of this research, the GISC classification is adopted for the sample distribution between sectors (for more details about the composition of sectors see Table 3.2). To control for the differences between sectors, following previous research, a series of nine dummy variables are developed (Dawkins & Fraas 2011; Reid & Toffel 2009). Given its similarities to the information technology sector, the telecommunications sector is excluded as reference sector.

It is documented in prior disclosure studies that firms enhance their reporting practices to mitigate ***asymmetric information problems*** between managers and external stakeholders. Clarkson et al. (2008), for instance, capture the information asymmetry factor by measuring the volatility of stock's returns and Tobin's *q*. Volatility (**S-VOLT**) is calculated as the twelve month volatility of stock's returns. In addition, Tobin's *q* captures the unbooked value of intangibles and net present value of investment opportunities. Tobin's *q* (**TOBIN's Q**) is measured as market value of common equity plus book value of preferred stock plus book value of long term debt and current liabilities, all divided by book value of total assets (Clarkson et al. 2008; Clarkson et al. 2011).

In relation to carbon emissions reduction and climate change abatement, the ***Kyoto protocol*** was developed in February 2005 to restrict GHGs emissions. Whilst this protocol is not compulsory, many countries have ratified it to show that they intend to limit their emissions. Hence, firms belonging to these countries are motivated to disclose more information about their efforts to reduce carbon emissions and consequently to mitigate climate change effects (Freedman & Jaggi 2005). Therefore, it is worthwhile to control for the potential effects of the Kyoto protocol

to diminish its effect on carbon disclosure (Freedman & Jaggi 2005, 2011; Prado-Lorenzo et al. 2009). **KYOTO** is a binary variable that equals one for firms from countries that have ratified the Kyoto protocol, zero otherwise.

Socio-political theories, especially legitimacy theory assume that environmental disclosure is a function of exposure to public pressure regarding environmental performance (Patten 2002). Therefore, these theories predict that firms with bad environmental records face more social pressure. This pressure motivates these firms to disclose more environmental information to mitigate this pressure and narrow the legitimacy gap. Hence, following Janis and Fadner (1965), Bansal and Clelland (2004), Aerts and Cormier (2009), and Clarkson et al. (2010), this study uses the ***J-F coefficient*** as carbon legitimacy measurement to capture social pressure and non-investor stakeholder perceptions about a firm's carbon risk management. This is achieved by analysing the content of favourable and unfavourable media news. This coefficient ranges from -1 (unfavourable) to +1 (favourable), with zero indicating neutral perceptions about the firm's carbon risk management. A search for archived articles written about each sample firm from the beginning of October 2008 until the end of August 2009 is conducted using the Factiva database. This search used the criterion of 'climate change'.

$$\text{Janis} - \text{Fadner coefficient} = \frac{(e^2 - ec)}{t^2} \qquad \text{If } e > c,$$

$$\text{Janis} - \text{Fadner coefficient} = \frac{(ec - c^2)}{t^2} \qquad \text{If } c > e,$$

$$\text{Janis} - \text{Fadner coefficient} = 0 \qquad \text{If } e = c$$

Where *e* is the number of favourable climate change related articles, *c* is the number of unfavourable articles, and *t* is *e* + *c*. Examples of favourable articles are carbon emissions reductions news, employing new energy efficiency technologies or recognition by a third party as a carbon and climate change responsible firm. Examples of unfavourable news are increase of carbon emissions, refusing or denying participation in carbon and climate change initiatives.

3.5.2 Financial performance determinants

Three common factors are identified in prior research as their influence on the ex-ante cost of equity capital. These are: firms' ***systematic risk (beta), book to market ratio, and size*** (Botosan & Plumlee 2002; Fama & French 1993; Francis et al. 2004). Firm's market risk is identified in the literature as being related to the cost of equity capital, whereby it represents market systemic risk (Botosan 1997; Botosan & Plumlee 2002; Dhaliwal et al. 2011; Plumlee et al. 2010; Plumlee, Brown & Marshall 2008). ***BETA*** is included in regression models to control for market systemic risk. It is estimated as the covariance of a firm's stock and market returns divided by the variance of a firm's stock returns.

$$\text{Beta} = \text{Cov}\,(R_s, R_m) / \text{Var}\,R_m$$

Where R_s is the returns on a firm's stock and R_m is the returns on the market. Beta is calculated on a weekly basis for the last twelve months. BETA is expected to be positively associated with the ex-ante cost of equity capital.

The expected rate of return (ex-ante cost of equity capital) has been found to be positively associated with the book to price ratio (referred to in some literature as book-to-market ratio) (Botosan & Plumlee 2002; Dhaliwal et al. 2011; Fama & French 1993; Plumlee et al. 2010; Plumlee, Brown & Marshall 2008). The rationale for this claim is that the book to market factor explains returns (Fama & French 1993). Given that a high book to market ratio indicates low returns (Fama & French 1992), firms with a high book to market ratio are expected to have high cost of equity capital. Book to price ratio **(BtoP)** is calculated as common equity's market value to common equity's book value.

In regards to the market valuation of carbon disclosure and risk management, two control variables are widely used in prior research. These variables are generated from Ohlson's (1995) valuation model, and are ***abnormal earnings (ABE), and book value of equity (BV)***. Ohlson (1995) argues that a firm's equity value is a function of its abnormal earnings and book value. Following Clarkson, Li and Richardson (2004), ***abnormal earnings*** is calculated as earnings to common equity less an assumed cost of equity capital based on r_{PEG} ratio times beginning-of-period book value of common equity, in US million dollars. The ***book value*** of common equity is estimated at the end of 2009 in US million dollars.

3.6 Empirical models for tests of hypotheses

All hypotheses that are developed in chapter 2 are tested using Ordinary Least Square (OLS) regressions. Thus, this section outlines the regression models employed to test these hypotheses.

3.6.1 The relationship between carbon risk management and carbon disclosure

To test hypothesis 1, which addresses the relationship between CRM and carbon disclosure, this study employs the following regression models, which are similar to that used by Clarkson et al. (2008):

$$CDIS1_{i,t} = \alpha_0 + \alpha_1 CRM_{i,t} + \alpha_2 ROE_{i,t} + \alpha_3 D\text{-}FIN_{i,t+1} + \alpha_4 S\text{-}FIN_{i,t+1} + \alpha_5 LEV_{i,t} + \alpha_6 SIZE_{i,t} + \alpha_7 KYOTO_{i,t} + \alpha_8 J\text{-}Fcoe_{i,t} + \alpha_9 S\text{-}VOLAT_{i,t} + \alpha_{10} TOBIN'SQ_{i,t} + \alpha_{11} \sum IND_{i,t} + \varepsilon_{i,t} \quad (3)$$

$$CDIS2_{i,t} = \gamma_0 + \gamma_1 CRM_{i,t} + \gamma_2 ROE_{i,t} + \gamma_3 D\text{-}FIN_{i,t+1} + \gamma_4 S\text{-}FIN_{i,t+1} + \gamma_5 LEV_{i,t} + \gamma_6 SIZE_{i,t} + \gamma_7 KYOTO_{i,t} + \gamma_8 J\text{-}Fcoe_{i,t} + \gamma_9 S\text{-}VOLAT_{i,t} + \gamma_{10} TOBIN'SQ_{i,t} + \gamma_{11} \sum IND_{i,t} + \varepsilon_{i,t} \quad (4)$$

Where:

$CDIS1_{i,t}$ = CDP carbon disclosure score (CDLI 2009) for firm *i* for year *t*,

$CDIS2_{i,t}$ = total weighted carbon disclosure score based on annual and sustainability reports and corporate websites for firm *i* for year *t*.

$CRM_{i,t}$ = carbon risk management score for firm *i* for year *t*.

$ROE_{i,t}$ = the ratio of net profit to shareholders' equity for firm *i* for fiscal year-end year *t*.

$D\text{-}FIN_{i,t+1}$ and $S\text{-}FIN_{i,t+1}$ = dichotomous variables equal 1 if the amount of debt and/or equity capital that is raised in 2010 is more than 5%, 0 otherwise.

$LEV_{i,t}$ = the total debt to total assets for firm *i* for fiscal year-end year *t*.

$SIZE_{i,t}$ = the log of total sales for firm *i* for fiscal year-end year *t*.

$IND_{i,t}$ = a series of nine industry dummy variables equal 1 if a firm is from a particular industry group, 0 = otherwise.

$S\text{-}VOLAT_{i,t}$ = the share price volatility for firm *i* for fiscal year-end year *t*.

TOBIN'S $Q_{i,t}$ is the ratio of the company stock market value to the total assets book value for firm *i* for fiscal year-end year *t*.

t and *t+1* = fiscal years 2009 and 2010 respectively.

3.6.2 The relationship between carbon disclosure and risk management and the ex-ante cost of equity capital

To examine the impact of carbon disclosure and carbon risk management on the E (Ke), as formulated in hypotheses 2a and 3a, this study employs the following two regression models. These models are based on those used by Richardson and Welker (2001), Botosan and Plumlee (2002), Plumlee, Brown, and Marshall (2008) Plumlee et al. (2010), and Dhaliwal et al. (2011).

$$E(Ke)_{i,t} = \beta_0+\beta_1 CDIS1_{i,t}+\beta_2 CRM_{i,t}+\beta_3 BETA_{i,t}+\beta_4 BtoP_{i,t}+\beta_5 SIZE_{i,t}+ \beta_6 \sum IND_{i,t}+\varepsilon_{i,t} \quad (5)$$

$$E(Ke)_{i,t}= \psi_0+\psi_1 CDIS2_{i,t}+\psi_2 CRM_{i,t}+\psi_3 BETA_{i,t}+\psi_4 BtoP_{i,t}+\psi_5 SIZE_{i,t}+\psi_6 \sum IND_{i,t}+ \varepsilon_{i,t} \quad (6)$$

Where:

$E(Ke)_{i,t}$ = the estimated ex-ante cost of equity capital for firm *i* for fiscal year-end year *t*.

$BETA_{i,t}$ = the systematic risk for firm *i* for fiscal year-end *t*.

$BtoP_{i,t}$ = book to price ratio for firm *i* for fiscal year-end *t*.

All other variables are as previously defined.

3.6.3 The relationship between carbon disclosure and risk management and firm's market value

To examine the impact of carbon disclosure and carbon risk management on a firm's market value stated in hypothesis 2b and 3b, un-deflated Ohlson's (1995) valuation model is adopted. This model has been widely used in the literature to test this association (Clarkson et al. 2010; Plumlee et al. 2010; Plumlee, Brown & Marshall 2008).

$$MV_{i,t} = \Omega_0 + \Omega_1 CDIS1_{i,t} + \Omega_2 CRM_{i,t} + \Omega_3 BV_{i,t} + \Omega_4 ABE_{i,t} + \Omega_5 \sum IND_{i,t} + \varepsilon_{i,t} \quad (7)$$

$$MV_{i,t} = \Phi_0 + \Phi_1 CDIS2_{i,t} + \Phi_2 CRM_{i,t} + \Phi_3 BV_{i,t} + \Phi_4 ABE_{i,t} + \Phi_5 \sum IND_{i,t} + \varepsilon_{i,t} \quad (8)$$

Where:

$MV_{i,t}$ = market value of common equity in US million dollars for firm *i* for fiscal year-end year *t*.

$BV_{i,t}$ = book value of common equity in US million dollars for firm *i* for fiscal year-end year *t*.

$ABE_{i,t}$ = abnormal earnings for firm *i* for fiscal year-end year *t*, defined as: earnings to common equity less an assumed cost of equity capital based on Easton's (2004) PEG ratio times the beginning of period book value of common equity, in US million dollars. All other variables are as defined above.

3.7 Chapter summary

This chapter outlines the methods that are used in this research and the justifications for choosing these methods. First, the sample on which the research is conducted is discussed. Second, the justifications for relying on archival data from CDP database and annual and sustainability reports, and the sources from which the data are

collected are noted. Third, the proxies and methods used to measure dependent and independent variables and the justification and advantages of these particular methods are explained. These variables are carbon risk management, carbon disclosure, ex-ante cost of equity capital, and market value. Fourth, control variables, their measurement, and the theoretical arguments for choosing these variables, are stated. Finally, regression models, which are used to test the research hypotheses, are formulated. The next chapter provide details of the descriptive statistics for dependent, independent and control variables.

CHAPTER 4 DESCRIPTIVE STATISTICS

4.1 Introductions

This chapter provides a description of data and variables used to test the study's hypotheses. Sections 4.2 and 4.3 provide the descriptive statistics for the dependent and independent variables, for the full sample and within country and industry. Section 4.4 discusses the descriptive statistics for the control variables. Section 4.5 concludes the chapter.

4.2 Descriptive statistics for carbon disclosure and risk management

Table 4.1 shows descriptive statistics for the dependent and independent variables. The first measure of carbon disclosure (CDIS1) has a mean of 64.39 and a median of 65.00. It ranges between 21 and 95, indicating considerable variation in the extent of disclosures made to CDP through their questionnaire. The second measure of carbon disclosure which was calculated from information provided in sustainability reports (CDIS2) is considerably lower with a mean (median) of 24.19 (25.00) and a range of 0 to 51. This difference between CDIS1 and CDIS2 scores derives mainly from a substantial amount of information being included in CDP responses while much less information is provided via publically available corporate disclosure channels. This difference may be due to the standards and degree of details required by certain guidance (such as GRI) differs from those required by CDP's questionnaire (Tran, Okafor & Herremans 2010). The minimum disclosure score for CDIS2 is zero indicating that some firms do not provide any carbon related information in their sustainability reports.

While it is not possible to detail the CDIS1 components since only the total score was provided by CDP, CDIS2 components are shown in Table 4.1 Panel B. Detailed disclosure scores were assigned based on sustainability reports. These scores were rewarded based on CDP 2009 scoring methodology (see chapter 3). The mean and median figures illustrate that the major contributor to disclosure scores is emissions information, while the lowest contributor is risks and opportunities' disclosures. This result is consistent with Doran and Quinn's (2009) results that S&P 500 corporations are still silent regarding the risks and opportunities posed by climate change.

Carbon risk management (CRM) has a mean of 54.77 and a median of 57.00. Scores range between 8 and 92, and the standard deviation for this variable is 18.55, indicating substantial differences in carbon risk management performance across sample firms.

With regard to ex-ante cost of equity capital, it is calculated based on Easton's (2004) method, which is referred to in the literature as r_{PEG} ratio (see model 1 chapter 3). The ex-ante cost of equity capital, E (Ke) statistics show a mean (median) of 0.099 (0.096), with a skewness of 1.663 and kurtosis of 5.473. It ranges from 0.01 to 0.34. This big variance reflects country differences between US and EU compared with Asia Pacific. The winsorisation technique is adopted to mitigate the potential impact of outliers. This approach is employed to avoid deleting more cases and keep the sample size consistent for all variables. Four cases ranging from 0.31 to 0.34 are winsorised in the right tail of the distribution to the value of 0.24. This process reduces the skewness from 1.663 to 0.927 and the kurtosis from 5.473 to 1.548.

Table 4.1 Descriptive statistics for dependent and independent variables for full sample

Variable	No	Mean	Median	Std. Dev	Min	Max	Skew	Kurt
Panel A: Descriptive statistics for carbon disclosure and risk management scores								
CDIS 1*	288	64.39	65.00	13.589	21	95	-0.235	-0.292
CDIS 2**	288	24.19	25.00	11.590	0	51	-0.166	-0.258
CRM***	288	54.77	57.00	18.547	8	92	-0.248	-0.495
Panel B: Descriptive statistics for detailed disclosure scores								
Risks &Opportunities	288	4.42	4.00	3.79	0	18	0.833	0.479
Emissions	288	14.09	14.00	7.13	0	37	-0.040	0.019
Verification &Trading	288	6.23	6.00	5.04	0	25	0.995	1.31
Performance	288	8.41	10.00	4.75	0	21	-0.611	-0.638
Governance	288	6.95	8.00	3.17	0	14	-0.332	0.069
Panel C: Descriptive statistics for stock market indicators								
E(Ke) (raw data)	288	0.099	0.096	0.048	0.01	0.34	1.663	5.473
E(Ke) (winsorised data)	288	0.098	0.096	0.043	0.01	0.24	0.927	1.548
MV (raw data) (in $ thousands)	288	4.55E7	2.97E7	4.47E7	$2,309,845	$360,295,094	2.775	10.737
MV(logged data)	288	7.52	7.47	0.328	6.363	8.556	0.496	0.236

***** Carbon disclosure scores awarded based on CDP questionnaire.
******Total Carbon disclosure scores awarded based on annual reports, sustainability reports and corporate websites.
******* Carbon risk management.

It is difficult to compare these statistics with prior research since this study is a cross-countries study, whereas most of the prior research was undertaken in USA and EU. Therefore, descriptive statistics within countries and industries are analysed in section 4.3.

Table 4.1 (Panel C) shows that market value has a mean (median) of $4,550,000 ($2,970,000), ranging from $2,309,845 to $360,295,094. This substantial variance leads to a skewness of 2.775 and a kurtosis of 10.737. To narrow this variance, the natural logarithm of the market value's raw data is estimated. This procedure decreases the skewness and kurtosis to 0.496 and 0.236 respectively.

Table 4.2 presents the descriptive statistics for the carbon disclosure scores for countries and sectors. Panels A and B of Table 4.2 report the descriptive statistics for carbon disclosure by country. It is clear that UK firms have the highest disclosure score based on the CDP questionnaire with a mean of 70.30, and that Others (South Africa and Brazil) and Asia and Pacific firms have the lowest scores with a mean of 59.50 and 61.87 respectively. However, the descriptive statistics for CDIS2 vary from those scores based on CDP except that UK's firms keep their position as the leaders in carbon disclosure with a mean of 32.15. While US firms were second in their CDP scores, they came last in their sustainability report scores with a mean of 18.66. The CDIS2 patterns are consistent with prior carbon and environmental disclosure research. According to CERES (2007) and Doran and Quinn (2009), US firms are still behind their counterparts in reporting their exposure to climate change and carbon emissions. In terms of environmental disclosure, most prior research has affirmed that Western Europe and Japanese' firms voluntarily disseminate more

environmental information than US firms (Jennifer Ho & Taylor 2007; Jose & Lee 2007; Saida 2009).

Panels C and D of Table 4.2 present the descriptive statistics for the full sample based on a firm's sector affiliation. Panel C shows descriptive statistics of disclosure based on CDP scores (CDIS1). Firms from the utilities sector have gained the highest scores with a mean of 66.78 and median of 67.50. Firms from the telecommunications sector have received the lowest scores with a mean of 55.11 and a median of 54.00.

Panel D presents the statistics for carbon disclosure scores that were awarded based on sustainability reports (CDIS2). The three sectors whose firms were awarded the highest scores are the materials sector with a mean (median) of 30.54 (29.00), followed by the utilities sector with a mean (median) of 29.00 (29.50) and finally the consumer discretionary sector with a mean (median) of 25.76 (28.00). On the other side, the three lowest scoring sectors are health care with a mean (median) of 19.00 (21.00), telecommunications 19.53 (21.00), and financials 21.89 (24.00). This order aligns with the assumption that high polluting firms are more likely to disclose emissions and environmental information than low polluting firms. According to Doran and Quinn (2009), firms from the utilities sector have spearheaded the discussion of climate change issues in their 10-k fillings in 2008.

Table 4.2 Climate change disclosure scores by country and industry for full sample

	N	Mean	Median	Std. Dev.	Minimum	Maximum
PANEL A: CDIS 1 scores by country						
North America	131	64.46	64.00	14.48	21	89
EU	78	64.09	63.00	12.52	35	95
UK	27	70.30	69.00	11.86	42	92
Asia & Pacific	46	61.87	63.00	12.92	41	87
Others*	6	59.50	61.00	15.02	39	74
Total	**288**					
PANEL B: CDIS 2 scores by country						
North America	131	18.66	19.00	11.37	0	48
EU	78	29.58	28.00	9.75	9	51
UK	27	32.15	31.00	7.15	20	49
Asia & Pacific	46	26.24	25.00	8.77	0	50
Others	6	23.50	25.50	17.24	0	43
Total	**288**					
PANEL C: CDIS 1 scores by industry						
Industrials	24	62.67	63.00	14.91	21	87
Consumer Discretionary	21	62.38	66.00	13.49	41	87
Consumer Staples	31	62.19	63.00	12.34	42	89
Energy	30	64.73	66.00	15.19	22	88
Financials	56	66.39	65.50	11.93	45	92
Materials	26	65.88	62.00	14.06	35	94
Telecommunications	19	55.11	54.00	11.97	39	73
Utilities	32	66.78	67.50	13.47	41	88
Healthcare	23	66.52	69.00	14.21	41	95
Information Technology	26	65.96	67.50	14.14	32	88
Total	**288**					
PANEL C: CDIS 2 scores by industry						
Industrials	24	24.00	24.00	12.580	0	51
Consumer Discretionary	21	25.76	28.00	11.55	9	50
Consumer Staples	31	22.87	24.00	7.99	0	36
Energy	30	25.47	25.00	10.86	6	43
Financials	56	21.89	24.00	10.76	0	46
Materials	26	30.54	29.00	9.97	11	49
Telecommunications	19	19.53	21.00	11.40	0	44
Utilities	32	29.00	29.50	12.25	6	49
Healthcare	23	19.00	21.00	11.79	0	46
Information Technology	26	23.92	26.50	13.76	0	44
Total	**288**					

* Others represent 6 firms from South Africa and Brazil.

Table 4.3 Carbon risk management scores by country and industry for full sample

	N	Mean	Median	Std. Dev.	Minimum	Maximum
PANEL A: CRM scores by country						
North America	131	49.90	49.00	19.39	8	92
EU	78	61.71	62.00	15.47	27	92
UK	27	66.19	68.00	13.09	43	92
Asia & Pacific	46	52.13	52.50	16.96	19	86
Others*	6	40.00	37.50	22.00	16	68
Total	**288**					
PANEL B: CRM scores by industry						
Industrials	24	56.38	57.00	16.71	22	86
Consumer Discretionary	21	52.48	54.00	24.26	8	92
Consumer Staples	31	55.13	51.00	14.70	32	86
Energy	30	51.77	54.00	21.19	8	86
Financials	56	55.07	58.00	17.86	19	92
Materials	26	61.27	61.50	14.64	22	89
Telecommunications	19	45.26	43.00	19.20	16	78
Utilities	32	58.16	58.00	19.69	19	92
Healthcare	23	47.48	49.00	16.82	11	76
Information Technology	26	60.31	59.00	17.42	22	89
Total	**288**					

* Others represent 6 firms from South Africa and Brazil.

Table 4.3 presents the carbon risk management (CRM) statistics. Panel A shows that firms from UK have obtained the highest scores with a mean of 66.19 and a median of 68.00. These scores indicate that UK firms are performing and dealing with carbon emissions and climate change risks and opportunities better than firms from other regions. These results are consistent with UK firms leading the sample in terms of their carbon disclosure (see Table 4.2). That is, this result gives an initial indication about the existence of a positive association between carbon disclosure and carbon risk management. In addition, it can be seen that country rankings for their CDIS1, CDIS2 and CRM scores is quite consistent with some deviation in CDIS1. This order is UK, EU, Asia and Pacific and lastly North America and Others. The UK and EU firms' leadership may result from the exposure of firms

from this area to the European Union Emissions Trading Scheme (EU ETS) and Carbon Reduction Commitment (CRC) scheme in UK.

Based on industry membership, the materials sector has achieved the highest scores with a mean of 61.27 and a median of 61.50. This indicates that this sector is the best in terms of its carbon risk management practices compared to other sectors. Whilst this sector's score was the fourth in its CDIS1, it is the first based on CDIS2 consistent with its CRM score. This comparison is valid since that the differences in emissions intensity between sectors are controlled in the CRM measure (see chapter 3, section 3.4.2)

4.3 Descriptive statistics for capital market indicators

To further analyse the descriptive statistics in Table 4.1 (Panel C), the ex-ante cost of equity capital and market value statistics were broken down and analysed based on country and sector affiliation. Table 4.4 monitors the raw data before the winsorisation process to show the natural characteristics of sample firms. As can be seen from Panel A, investors from Others (South Africa and Brazil) and UK tend to require higher risk premia than their counterparts from other continents. The mean (median) in Others and UK are 0.140 (0.140) and 0.114 (0.094) respectively, whereas the mean (median) are 0.096 (0.098), 0.096 (0.095) and 0.096 (0.088) for USA, EU and Asia and Pacific respectively. The mean (median) of E (Ke) in North America is 0.096 (0.098), with a minimum of 0.01 and maximum of 0.34. These figures are approximately consistent with those reported by Clarkson et al. (2010) with a mean (median) of 0.10 (0.09), and a minimum (maximum) of 0.03 (0.28). The difference between maximum values can be attributed to two reasons. First, the

Clarkson et al. (2010) study was conducted based on data related to 2004 and 2007, whereas this study is based on 2009 data. Second, the increase in the maximum value for the ex-ante cost of equity capital (34 per cent) is related to firms from the financials sector. These firms may be considered as risky firms due to their exposure to the financial crisis. The minimum values indicate that other financial firms have low ex-ante cost of equity capital.

Panel B shows that the materials and financials sectors have the highest risk premiums. The mean and median of ex-ante cost of equity capital for the materials sector are 0.123 and 0.110 respectively, whereas the mean (median) for the financials sector is 0.121 (0.112). Alternatively, the telecommunications and utilities sectors have the lowest risk premiums. These results, however, are contradictory to some of those found in the literature. Daske, Gebhardt and Klein (2006) for example, find that the information technology and electronic equipment sectors have the highest cost of equity capital; whereas the utilities and financials sectors experience the lowest cost of capital. This may be due to time differences between studies and exposure to the financial crisis.

Table 4.4 (Panels C and D) reports the descriptive statistics for market value by country and industry, indicating substantial variation in this value. These statistics display the raw data rather that the logged one since it adequately and accurately shows the natural characteristics of the sample firms. Panel C illustrates that US firms have the highest market value, with a maximum values of $360,295,094.

Table 4.4 Descriptive statistics for dependent and independent variables for full sample

	N	Mean	Median	Std. Dev.	Minimum	Maximum
PANEL A: E(Ke) descriptive statistics by country						
North America	131	0.096	0.098	0.037	0.01	0.34
EU	78	0.096	0.095	0.047	0.01	0.24
UK	27	0.114	0.094	0.053	0.04	0.32
Asia & Pacific	46	0.096	0.088	0.046	0.02	0.31
Others*	6	0.140	0.140	0.035	0.10	0.20
Total	**288**					
PANEL B: E(Ke) descriptive statistics by industry						
Industrials	24	0.097	0.106	0.031	0.02	0.16
Consumer Discretionary	21	0.103	0.102	0.032	0.04	0.18
Consumer Staples	31	0.082	0.083	0.018	0.04	0.12
Energy	30	0.106	0.109	0.039	0.02	0.17
Financials	56	0.121	0.112	0.056	0.01	0.34
Materials	26	0.123	0.110	0.044	0.03	0.31
Telecommunications	19	0.072	0.072	0.030	0.02	0.13
Utilities	32	0.074	0.056	0.042	0.02	0.23
Healthcare	23	0.082	0.086	0.026	0.01	0.13
Information Technology	26	0.099	0.100	0.040	0.03	0.24
Total	**288**					
PANEL C: MV descriptive statistics by country						
North America	131	$4.64E7	$2.66E7	$5.25E7	$10,424,701	$360,295,094
EU	78	$4.76E7	$3.89E7	$3.50E7	$9,717,408	$177,806,893
UK	27	$5.51E7	$3.92E7	$5.25E7	$6,522,755	$203,136,807
Asia & Pacific	46	$3.48E7	$2.35E7	$2.62E7	$2,309,845	$138,474,537
Others*	6	$2.76E7	$2.35E7	$1.22E7	$18,897,124	$51,127,362
Total	**288**					
PANEL D: MV descriptive statistics by industry						
Industrials	24	$3.12E7	$2.45E7	$1.84E7	$10,506,680	$84,710,876
Consumer Discretionary	21	$3.74E7	$3.51E7	$2.77E7	$6,522,755	$138,474,537
Consumer Staples	31	$5.18E7	$3.61E7	$5.01E7	$12,353,120	$210,713,066
Energy	30	$6.26E7	$3.11E7	$7.42E7	$12,668,652	$360,295,094
Financials	56	$4.24E7	$3.52E7	$3.48E7	$2,309,845	$199,786,337
Materials	26	$3.52E7	$2.63E7	$2.23E7	$10,824,431	$94,546,715
Telecommunications	19	$4.89E7	$3.27E7	$4.23E7	$11,818,234	$169,995,195
Utilities	32	$2.57E7	$1.88E7	$2.06E7	$10,424,701	$98,612,180
Healthcare	23	$5.95E7	$3.83E7	$5.18E7	$13,894,903	$191,335,000
Information Technology	26	$6.46E7	$3.78E7	$5.83E7	$14,680,848	$217,027,069
Total	**288**					

*Others represent 6 firms from South Africa and Brazil. Minimum and maximum values of MV are in $ thousands.

Panel D (Table 4.4) indicates that the energy and information technology sectors have the highest market value with maximum values of $360,295,094 and $217,027,069 respectively. In addition, Panel D shows that the industrials and materials sectors have the lowest market value with maximum values of $84,710,876 and $94,546,715 respectively.

4.4 Descriptive statistics for control variables

This section presents the descriptive statistics for control variables that are identified in the literature due their potential impact on the dependent variables of this study. It summarises the raw data distributions and the techniques used to mitigate outlier problems.

ROE shows a mean (median) of 0.164 (0.1239), with skewness of 5.379 and kurtosis 45.728. To reduce the impact of outliers, data is transformed using the winsorisation technique. Ten values ranging from 0.59 to 2.47 are winsorised in the right tail of the distribution and one value (-0.28) is winsorised to the left tail of the distribution. This process decreased the kurtosis from 45.728 to 2.234.

LEV has a range of 0.00 to 0.58 with a mean of 0.219 and median of 0.220. This implies that the LEV data has low skewness and kurtosis with skewness of 0.256 and kurtosis of -0.329. Therefore, there is no need to transform the LEV data. The number of firms for this variable is decreased from 288 to 230 since financial and health insurance firms have different reporting requirements. Hence, 58 firms' data (56 values from the financials sector and 2 values relate to two life insurance firms from the health care sector) is considered as missing data. For robustness purposes,

two additional tests are conducted to ensure that these missing values have no impacts on final results (see chapter five).

SIZE is proxied as the total sales in US millions dollars. It has a high skewness and kurtosis of 3.860 and 21.471 respectively. Therefore, total sales are transformed by taking their natural log to mitigate the skewness problems. This process resulted in transformed data with a mean of 7.344 and a median of 7.346. Logged total sales display an approximate normal distribution with skewness of 0.042 and kurtosis of -0.147.

J-Fcoe coefficient refers to a firm's carbon legitimacy. This variable ranges from 1.00 to -1.00. This range indicates that 1.00 when all articles that written about a firm are good, whereas -1.00 is all articles about firm's relevant carbon and climate change activities are bad. Out of 739 articles, 576 articles are classified as favourable articles; whereas 163 are classified as unfavourable articles. J-Fcoe has a mean (median) of 0.39 (0.12).

Table 4.5 Descriptive statistics for control variables

Panel A Continuous variables								
Variable	**No**	**Mean**	**Median**	**Std. Dev.**	**Min**	**Max**	**Skew**	**Kurt**
ROE	288	0.164	0.123	0.223	-0.28	2.47	5.379	45.728
ROE (winsorised data)	288	0.149	0.123	0.138	-0.16	0.57	1.235	2.234
LEV	230	0.219	0.220	0.131	0.00	0.58	0.256	-0.329
Total Sales (in $ thousands)	288	$3.65E7	$2.22E7	$4.59E7	$1.340	$405,046	3,860	21.471
SIZE (Log of sales)	288	7.344	7.346	0.432	6.236	8.479	0.042	-0.147
J-Fcoe	288	0.39	0.12	0.526	-1.00	1.00	-0.180	-0.730
S-VOLAT	287	0.50	0.46	0.219	0.15	1.49	1.440	2.988
S-VOLAT(winsorised data)	287	0.49	0.46	0.205	0.15	1.12	1.044	0.988
TOBIN'SQ	288	1.41	1.18	0.884	0.17	7.05	2.116	7.702
TOBIN'SQ (winsorised data)	288	1.38	1.18	0.777	0.17	3.69	1.124	0.809
BETA	287	1.01	0.94	0.57	0.05	3.18	1.049	1.154
BtoP	287	0.67	0.52	0.75	-0.27	9.11	6.649	63.981
BtoP (winsorised data)	287	0.62	0.52	0.44	-0.27	2.11	1.523	2.590
BV (in millions)	288	$2.70E7	$1.55E7	$3.18E7	$-3,993,516	$231,463,933	2.722	9.323
BV (logged data)	287	7.222	7.199	0.418	6.016	8.364	0.244	-0.200
ABE (in millions)	288	6.90E7	2.03E7	$1.85E8	-1.35E8	2.05E9	6.897	62.416
ABE (logged data)	259	7.333	7.405	0.830	2.67	9.31	-1.469	6.446

Panel B Dichotomous variables			
Variable	**No**	**Frequency of 1s**	**Frequency of 0s**
D-FIN	232	146 (63%)	86 (37%)
S-FIN	288	33 (11.46%)	255 (88.54%)
Kyoto Protocol	288	177 (61.46%)	111 (38.54%)

Descriptive statistics for Share volatility **(S-VOLAT)** show a mean of 0.50 and a median of 0.46, with skewness and kurtosis of 1.440 and 2.988 respectively. This skewness and kurtosis is due to six outliers, which range from 1.18 to 1.49. To mitigate the potential impact of outliers on results, these six values are winsorised from the right tail of the distribution. The winsorisation process reduces the kurtosis from 2.988 to 0.988. **Tobin's *q*** shows a mean of 1.41 and median of 1.18, with skewness 2.116 and kurtosis of 7.702. The kurtosis is due to five outliers (ranging from 4.11 to 7.05). These values are winsorised from the right tail to reduce the potential impact of outliers. This process results in reducing kurtosis from 7.702 to 0.809.

Firms' systematic risk (as expressed as **BETA**) displays an acceptable normal distribution. This is evident by a mean of 1.01 and a median of 0.94, with a skewness of 1.049 and a kurtosis of 1.154. This BETA's mean is consistent with that found in Orens, Aerts and Cormier (2010) for pooled sample in 2002. Table 4.5 shows that the **BtoP** ratio has a mean (median) of 0.67 (0.52), with a skewness of 6.649 and a kurtosis of 63.981. These statistics are, to some extent, reasonable since this big variance resulted from the decrease of book value of financial firms' shares compared to the market value. Six extreme values (representing six banks from UK, USA and Japan) range from 2.31 to 9.11. Winsorisation from the right tail of the distribution is conducted, which results in a kurtosis reduction from 63.981 to 2.590.

BV variable shows a mean of $2.70E7 and a median of $1.55E7. This is associated with skewness of 2.722 and kurtosis of 9.323. The natural logarithm of book value in US million dollars is taken to reduce their potential impact on the analysis. This

process results in a data with a skewness of 0.244 and kurtosis of -0.200. Descriptive statistics for **ABE** show a mean (median) of $6.90E7 ($2.03E7), with a skewness of 6.897 and kurtosis of 62.416. To reduce these extreme values' impact, the natural logarithm of this data is conducted. This process produced a data with a skewness of -1.469 and kurtosis of 6.446.

Table 4.5 (Panel B) presents descriptive statistics for the dichotomous variables. For the **D-FIN**, out of 232 firms, 146 firms raised their debt in 2010, whereas 86 did not. It should be noted here that the full sample is 288 firms, and 56 firms that belong to the financials sector are considered as missing values for this variable. In contrast, for the **S-FIN**, only 33 firms have issued new shares during 2010. Previous statistics illustrate that the propensity of global firms on relying on debt finance is greater than that relying on shares (equity) finance. With respect to the Kyoto protocol (**KYOTO**), out of 288 firms, 177 belong to countries that ratified the Kyoto protocol, whereas 111 belong to other countries. These are USA-based firms. Finally, for the firms' distribution between sectors see Table 3.2 of chapter 3).

4.5 Chapter summary

This chapter discusses in details the descriptive statistics of dependent, independent and control variables. These statistics include the dependent and independent variables characteristics within full sample and country and industry classifications. Additionally, it discusses transformation techniques used to mitigate the impact of outliers and skewness. Further, this chapter provides descriptive statistics relevant to control variables and transformation approaches employed to diminish potential

distributional problems. The next chapter presents the main results obtained from testing this study's hypotheses.

CHAPTER 5 DATA ANALYSIS AND RESULTS

5.1 Introduction

This chapter provides the main results from the statistical tests. The focus of this chapter, therefore, is to present the correlations and regressions conducted to test this study's hypotheses. This chapter is organised as follows: section 5.2 explains the results obtained from examining the relationship between carbon risk management and carbon disclosure; section 5.3 presents the results from testing the association between the ex-ante cost of equity capital and carbon disclosure and carbon risk management; section 5.4 discusses the results from tests of the association between firms' market value and carbon disclosure and carbon risk management; section 5.5 summarises the chapter's main themes.

5.2 Empirical results for the relationship between carbon risk management and carbon disclosure (H1)

Given the conflict between socio-political and economic-based disclosure theories, no directional prediction is made about the relationship between carbon risk management and carbon disclosure. The resulted sign will support one of these two sets of theoretical assumptions. Therefore the first hypothesis is stated in the following form:

H1 - There is a relationship between carbon risk management and the quality of carbon disclosure.

The following sections discuss the empirical results from testing this hypothesis. These results include the correlation (bivariate) results, regression (multivariate) results, and sensitivity tests.

5.2.1 Correlation results for hypothesis 1

This section provides the results of the correlation between carbon risk management (CRM), the two proxies for carbon disclosure (CDIS1 and CDIS2), and control variables. Table 5.1 (Panels A and B) show Pearson and Spearman correlations between carbon disclosure and carbon risk management. Panel A presents the correlation based on CDP disclosure (CDIS1). Pearson correlation show a high positive relationship, with a coefficient of 0.527 observed between carbon disclosure via the CDP questionnaire and carbon risk management. Spearman coefficients show similar results with those of Pearson correlations with a coefficient of 0.535. Hence, these results indicate preliminary support for the first hypothesis, which suggests the existence of an association between carbon risk management and disclosure. Moreover, the positive sign of this correlation supports the argument of economic-based disclosure theories while concurrently rejecting the socio-political theories' claims. Superior firms in terms of their carbon risk management practices provide high quality information about these practices.

In addition, based on Pearson and Spearman coefficients, two control variables exhibit high positive associations with the CDP disclosure measure. These are firm size and carbon legitimacy (J-Fcoe) with correlation coefficients of 0.171 and 0.187 respectively for Pearson correlations and 0.163 and 0.202 for Spearman correlations. This suggests that larger firms release more climate change information. In addition,

these firms are highly exposed to the media, which in turn is reflected in more information released to CDP. S-FIN and S-VOLAT are weakly positively associated with carbon disclosure when Spearman correlations are considered. However, they are insignificant based on Pearson correlations.

Panel B of Table 5.1 Pearson and Spearman correlations show a significant positive association between carbon disclosure via sustainability reports and carbon risk management, with coefficients of 0.625 and 0.631 respectively. These coefficients also support the theoretical stance of economics-based disclosure theories. In addition, Pearson and Spearman correlations show that some control variables are positively and significantly associated with carbon disclosure. These variables are firm size, the ratification of the Kyoto protocol, and carbon legitimacy. These associations give support to prior research about environmental disclosure determinants. TOBIN's Q exhibits conflicting results. While it is negatively and significantly associated with CDIS2 based on Pearson correlations, it is insignificant based on Spearman correlations. Finally, the insignificant correlation between carbon disclosure and profitability, finance incentives and leverage are, to some extent, consistent with previous studies where some have found significant associations and other studies have not.

Table 5.1 shows some inter-correlations among independent and control variables indicating that there is potential for multicollinearity. Therefore, Variance Inflation

Factor[5] (VIF) analysis is systemically conducted to measure the impact of collinearity among the variables in all regression models.

5.2.2 Regression results for hypothesis 1 (full sample)

As discussed in chapter 4, D-FIN and LEV variables have many missing values (for more details see descriptive statistics section in chapter 4) relevant to the financials sector. These two variables were not found to be significantly correlated with the dependent variables in correlation results discussed in the previous section. Therefore, to avoid any impact of these missing values on the results, hypothesis 1 is tested by excluding these two variables from the regression models.

Regression results after excluding D-FIN and LEV variables are shown in Table 5.2. With respect of CDIS1, model 3 is highly significant with an adjusted R^2 of 0.298, F statistic of 8.143 and *P*-value of 0.000. In addition, the significant association between CRM and CDIS1 supports hypothesis 1 of this study about the existence of such a relationship. This association is significant at the 0.001 level with a positive sign. This result is congruent with economics-based disclosure theories (voluntary disclosure theory and signalling theory) (Akerlof 1970; Clarkson et al. 2008; Dye 1985; Levin 2001; Morris 1987; Ross 1977; Toms 2002; Verrecchia 1983). High quality firms in terms of their carbon risk management practices have an incentive to disclose credible information about their carbon activities than low quality firms.

[5] There is a lack of consistency about the maximum acceptable value of this factor. While Branco and Rodrigues (2008) and Sharfman and Fernando (2008) claim that The VIF should be less than 2, Hair et al. (2006) and Clarkson et al. (2010) and Busch and Hoffmann (2011) note that this factor should be less than 5 to affirm that multicollinearity does not constitutes a big concern.

Table 5.*1* Correlation matrix: (Pearson above diagonal, Spearman below)

$CDIS1_{i,t}=\alpha_0+\alpha_1 CRM_{i,t}+\alpha_2 ROE_{i,t}+\alpha_3 D\text{-}FIN_{i,t+1}+\alpha_4 S\text{-}FIN_{i,t+1}+\alpha_5 LEV_{i,t}+\alpha_6 SIZE_{i,t}+\alpha_7 KYOTO_{i,t}+\alpha_8 J\text{-}Fcoe_{i,t}+\alpha_9 S\text{-}VOLAT_{i,t}+\alpha_{10} TOBIN'SQ_{i,t}+\alpha_{11}\sum IND_{i,t}+\varepsilon_{i,t}$

$CDIS2_{i,t}=\gamma_0+\gamma_1 CRM_{i,t}+\gamma_2 ROE_{i,t}+\gamma_3 D\text{-}FIN_{i,t+1}+\gamma_4 S\text{-}FIN_{i,t+1}+\gamma_5 LEV_{i,t}+\gamma_6 SIZE_{i,t}+\gamma_7 KYOTO_{i,t}+\gamma_8 J\text{-}Fcoe_{i,t}+\gamma_9 S\text{-}VOLAT_{i,t}+\gamma_{10} TOBIN'SQ_{i,t}+\gamma_{11}\sum IND_{i,t}+\varepsilon_{i,t}$

Panel A: Correlation coefficients based on CDP disclosure											
	CDIS1	**CRM**	**ROE**	**D-FIN**	**S-FIN**	**LEV**	**SIZE**	**KYOTO**	**J-Fcoe**	**S-VOLAT**	**TOBIN's Q**
CDIS1 (+)	1	0.527**	0.055	-0.039	0.112	0.029	0.171**	-0.024	0.187**	0.116	-0.030
CRM (+)	0.535**	1	0.028	0.020	0.080	0.021	0.351**	0.185**	0.262**	-0.002	-0.100
ROE (+)	0.069	-0.012	1	-0.72	-0.060	0.085	0.029	-0.168**	-0.060	-0.363**	0.516**
D-FIN (+)	-0.038	0.041	-0.007	1	0.064	-0.093	-0.052	-0.109	0.157*	0.010	0.096
S-FIN (+)	0.119*	0.075	-0.081	0.064	1	-0.093	-0.047	0.106	-0.075	0.315**	-0.034
LEV (+)	0.050	0.033	-0.019	-0.099	- 0.079	1	0.006	-0.005	0.094	-0.097	-0.354**
SIZE (+)	0.163**	0.324**	-0.019	-0.058	- 0.024	0.008	1	0.123*	0.177**	-0.020	-0.259**
KYOTO (+)	-0.030	0.200**	-0.198**	-0.109	0.106	-0.014	0.142*	1	-0.105	-0.081	-0.212**
J-Fcoe (-)	0.202**	0.285**	-0.060	0.165*	- 0.068	0.116	0.225**	-0.105	1	-0.064	-0.065
S-VOLAT (+)	0.127*	0.028	-0.328**	0.019	0.247**	-0.103	-0.001	-0.104	-0.055	1	-0.300**
TOBIN's Q(+)	-0.048	-0.139*	0.553**	0.101	- 0.097	-0.360**	-0.249**	-0.233**	-0.053	-0.305**	1
Panel B: Correlation coefficients based on annual and sustainability reports and corporate websites disclosures											
	CDIS2	**CRM**	**ROE**	**D-FIN**	**S-FIN**	**LEV**	**SIZE**	**KYOTO**	**J-Fcoe**	**S-VOLAT**	**TOBIN's Q**
CDIS2 (+)	1	0.625**	0.005	-0.065	0.017	0.046	0.312**	0.390**	0.210**	-0.087	-0.133*
CRM (+)	0.631**	1	0.028	0.020	0.080	0.021	0.351**	0.185**	0.262**	-0.002	-0.100
ROE (+)	-0.022	-0.012	1	-0.072	-0.060	0.085	0.029	-0.168**	-0.060	-0.363**	0.516**
D-FIN (+)	-0.052	0.041	-0.007	1	0.064	-0.093	-0.052	-0.109	0.157*	0.010	0.096
S-FIN (+)	0.022	0.075	-0.081	0.064	1	-0.093	-0.047	0.106	-0.075	0.315**	-0.034
LEV (+)	0.066	0.033	-0.019	-0.099	-0.079	1	0.006	-0.005	0.094	-0.097	-0.354**
SIZE (+)	0.305**	0.324**	-0.019	-0.058	-0.024	0.008	1	0.123*	0.177**	-0.020	-0.259**
KYOTO (+)	0.380**	0.200**	-0.198**	-0.109	0.106	-0.014	0.142*	1	-0.105	-0.081	-0.212**
J-Fcoe (-)	0.229**	0.285**	-0.060	0.165*	-0.068	0.116	0.225**	-0.105	1	-0.064	-0.065
S-VOLAT (+)	-0.062	0.028	-0.328**	0.019	0.247**	-0.103	-0.001	-0.104	-0.055	1	-0.300**
TOBIN's Q(+)	-0.105	-0.139*	0.553**	0.101	-0.097	-0.360**	-0.249**	-0.233**	-0.053	-0.305**	1

**,* represent significant levels at 0.01 and 0.05 (two-tailed) respectively.

Variables definition: **CDIS1** is the carbon disclosure scores obtained from CDLI 2009; **CDIS2** is the carbon disclosure scores based on annual and sustainability reports and corporate websites; **CRM** is the carbon risk management scores; **ROE** is the ratio of net profit to shareholders' equity. **D-FIN** and **S-FIN** are binary variables that eqal1 if debt or shares capital raised in 2010, 0 otherwise; **LEV** is the ratio of total debt to total assets; **SIZE** is the natural logarithm of total sales; **KYOTO** is a binary variable for firms from countries that ratified and did not ratify the Kyoto protocol. **J-Fcoe** is the Janis-Fadner coefficient; **S-VOLAT** is the twelve months' volatility of stock's returns; **TOBIN'S Q** is the sum of market value of common equity, book value of preferred stock and book value of long term debt and current liability divided by book value of total assets. **IND** is a series of nine industry dummy variables: 1 = a company was from a particular industry group and 0 = otherwise. The Telecommunications sector is excluded as reference sector.

These firms are doing so to mitigate information asymmetry problems and to differentiate themselves from poor quality firms. On the other hand, the insignificant association between carbon disclosures made via the CDP questionnaire and the carbon legitimacy proxy (J-Fcoe) suggests that social pressure has no role in determining carbon disclosure to CDP. In respect of control variables, none of them are significantly associated with CDIS1. This suggests that carbon risk management is the main driver of carbon disclosure via CDP.

With regard of CDIS2, Table 5.2 reveals that model 4 is highly significant with an adjusted R^2 of 0.512, F statistic of 18.659 and *P*-value of 0.000. Once again, in support of hypothesis one, a positive and significant association between CDIS2 and CRM is observed. Also, consistent with CDIS1 results, the carbon legitimacy proxy is not significant. This result indicates that social and political pressure does not play a major role in influencing the tendency to disclose carbon information when other factors are controlled.

These results are consistent with some related prior research. With regard to environmental disclosure, the positive relationship observed in this study parallels the results of Al-Tuwaijri, Christensen and Hughes (2004) and Clarkson et al. (2008) who find a similar result but in terms of environmental performance and disclosure. In addition, this study's results are consistent with those of Dawkins and Fraas (2011) and Matsumura, Prakash and Vera-Muñoz (2011), but with a different measurement of carbon disclosure and performance.

Table 5.2 Regression results for the relationship between carbon disclosure and carbon risk management (full sample)

$CDIS1_{i,t} = \alpha_0 + \alpha_1 CRM_{i,t} + \alpha_2 ROE_{i,t} + \alpha_3 D\text{-}FIN_{i,t+1} + \alpha_4 S\text{-}FIN_{i,t+1} + \alpha_5 LEV_{i,t} + \alpha_6 SIZE_{i,t} + \alpha_7 KYOTO_{i,t} + \alpha_8 J\text{-}Fcoe_{i,t} + \alpha_9 S\text{-}VOLAT_{i,t} + \alpha_{10} TOBIN'SQ_{i,t} + \alpha_{11} \sum IND_{i,t} + \varepsilon_{i,t}$

$CDIS2_{i,t} = \gamma_0 + \gamma_1 CRM_{i,t} + \gamma_2 ROE_{i,t} + \gamma_3 D\text{-}FIN_{i,t+1} + \gamma_4 S\text{-}FIN_{i,t+1} + \gamma_5 LEV_{i,t} + \gamma_6 SIZE_{i,t} + \gamma_7 KYOTO_{i,t} + \gamma_8 J\text{-}Fcoe_{i,t} + \gamma_9 S\text{-}VOLAT_{i,t} + \gamma_{10} TOBIN'SQ_{i,t} + \gamma_{11} \sum IND_{i,t} + \varepsilon_{i,t}$

variable	**Regression results based on CDP disclosure (CDIS1, model 3)**			**Regression results based on sustainability reports disclosures (CDIS2, model 4)**		
	Coefficient	**t-value**	***P*- value**	**Coefficient**	**t-value**	***P*- value**
Intercept	30.177	2.117	0.035	-15.648	-1.543	0.124
CRM	0.386	9.068	0.000**	0.304	10.051	0.000**
ROE	6.328	0.997	0.319	8.957	1.984	0.048*
S-FIN	1.544	0.671	0.503	-1.017	-0.621	0.535
SIZE	0.525	0.276	0.783	2.024	1.497	0.135
KYOTO	-2.134	-1.345	0.180	7.367	6.525	0.000**
J-Fcoe	1.435	1.033	0.303	1.747	1.768	0.078
S-VOLAT	6.622	1.353	0.177	-1.859	-0.534	0.594
TOBON's Q	1.033	0.744	0.458	-1.085	-1.098	0.273
Industrials	1.869	0.517	0.606	2.664	1.036	0.301
Consumer Discretionary	2.508	0.658	0.511	7.384	2.721	0.007*
Consumer Staples	1.759	0.508	0.612	2.562	1.039	0.300
Energy	5.485	1.533	0.126	6.912	2.716	0.007*
Financials	6.014	1.650	0.100	1.601	0.617	0.537
Materials	2.745	0.709	0.479	8.862	3.216	0.001*
Utilities	6.355	1.836	0.067	7.541	3.063	0.002*
Health Care	8.075	2.187	0.030*	3.095	1.178	0.240
Information Technology	2.329	0.620	0.536	3.911	1.462	0.398
Adj.R^2	0.298			0.512		
F-statistic	8.143**			18.659**		

**,* represent significance levels at 0.001 and 0.05 respectively

Variables definition: CDIS1 is the carbon disclosure scores obtained from CDLI 2009; CDIS2 is the carbon disclosure scores based on annual and sustainability reports and corporate websites; CRM is the carbon risk management scores; ROE is the ratio of net profit to shareholders' equity. S-FIN is binary variables that eqal1 if shares capital raised in 2010, 0 otherwise; SIZE is the natural logarithm of total sales; KYOTO is a binary variable for firms from countries that ratified and did not ratify the Kyoto protocol. J-Fcoe is the Janis-Fadner coefficient; S-VOLAT is the twelve months' volatility of stock's returns; TOBIN'S Q is the sum of market value of common equity, book value of preferred stock and book value of long term debt and current liability divided by book value of total assets. IND is a series of nine industry dummy variables: 1 = a company was from a particular industry group and 0 = otherwise. The Telecommunications sector is excluded as reference sector. VIF values are all lower than 3.0 except for the Financials industry with values of 4.611 in both of CDIS1and CDIS2 models.

While these studies have adopted the carbon emission levels as performance, the current study employs more comprehensive definition of carbon and climate change performance (see chapter 3). In addition, most previous research was conducted on one country, mostly the USA. However, this study's results can be generalised globally since its sample was drawn from the G500 firms worldwide.

For control variables, in contrast to results for CDP disclosure, model 4 shows that some control variables are significantly associated with CDIS2. Firms' profitability (ROE) is positively and significantly associated with CDIS2, suggesting that firms with high profitability are more likely to disclose their good carbon risk management activities information. Additionally, consistent with Freedman and Jaggi (2005, 2011) and Prado-Lorenzo et al. (2009), the ratification of the Kyoto protocol is significantly positive at the 0.001 level. This result indicates firms belong to countries that ratified the Kyoto protocol are more forthcoming in releasing an objective carbon information via their sustainability report. When industry is considered, firms in the energy, materials and utilities sectors tend to have significantly higher disclosure scores. This result seems intuitive since these sectors are considered as carbon-intensive sectors.

Finally, all other control variables are not significant. Consistent results are observed for these control variables regardless of whether the disclosure was made via CDP or firms' mainstream reporting. Interestingly, contrary to previous studies, there is no statistical support for the contention that large firms are motivated to disclose more carbon information. The possible interpretation for this result is that all firms under analysis are large as they were drawn from G500. Finally, information asymmetry

proxies (Tobin's *q* and Volatility) are insignificant for both disclosure channels. This is consistent with Clarkson et al.'s (2008) findings and the claim that firms use several channels to convey their carbon activities, which in turn reduces the information asymmetry between insiders and outsiders.

5.2.3 Sensitivity tests

To test the robustness of the conclusions for hypothesis 1, an additional test is conducted by including the D-FIN and LEV while simultaneously excluding the financial sector's firms from the sample under analysis. This process results in sample reduction to 232 firms. Untabulated regression results obtained from this analysis are consistent with those reported in Table 5.2. For the association between CRM and CDIS, these results support the assumption of a positive relationship between carbon risk management and carbon disclosure via CDP and sustainability reports. In addition, with regard to the control variables, all control variables show similar patterns. While none of control variables are significant with CDIS1, ROE and KYOTO variables are positively and significantly associated with CDIS2 with *P*-value of 0.048 and 0.000 respectively. In addition, Consistent with Luo, Lan and Tang (2010) results, incentives to obtain new finance (debt and equity finance D-FIN and S-FIN) are not a significant determinant of carbon disclosure. Similarly, the estimated coefficient of leverage (LEV) is insignificant. This result is consistent with the literature (Freedman & Jaggi 2005; Prado-Lorenzo et al. 2009; Stanny & Ely 2008), and indicates that debt holders do not exert pressure on firms to disclose carbon related information.

5.2.4 Regression results based on disaggregated carbon risk management and disclosure scores

Hypothesis 1 is re-examined to check whether the results obtained from previous tests based on total CDIS2 scores are consistent when carbon disclosure scores and risk management are partitioned to their components. According to the Carbon Disclosure Index Leaders 2009 methodology, the total weighted disclosure and risk management scores that are awarded to firms can be sub-totalled to five categories. These are risk and opportunities, emissions accounting, verification and trading, performance, and finally governance. Two analyses are performed to make a robust conclusion about previous results. First, each of these categories is regressed on the firm's carbon risk management total score and control variables from model 4. This analysis is conducted only on model 4 since the detailed CDIS1 scores are proprietary, and therefore were not available to the researcher.

Second analysis is undertaken by regressing each disclosure category with its matched risk management category. This process is adopted to check whether firms' management are interested in particular category of carbon risk management and disclosure. Indeed, vice versa, managers may interested in disclosing historical carbon risk management information (historical information) rather than in their commitment and future strategies adopted to reduce carbon emissions level and minimise climate change associated risks (forward looking information) .

With regard to the first analysis, Table 5.3 shows that the CRM coefficients for all carbon disclosure categories are positive and significant at the 0.001 level. This implies that firms with good carbon risk management records disseminate carbon

information about several aspects of their climate change performance. Indeed, firms with better carbon risk management practices rely more on releasing detailed and high carbon disclosure quality (hard disclosure). This analysis' findings are similar to those of Clarkson et al. (2008) and Clarkson, Overell and Chapple (2011) about the role of environmental performance in enhancing hard or credible disclosure.

Interestingly, control variables show different association patterns with the various carbon disclosure components. For the disclosure about climate change risks and opportunities, several other determinates appear to explain the incentives for such disclosure. These are firms' profitability, ratification of the Kyoto protocol, and interestingly the carbon legitimacy proxy. This suggests that in addition to carbon risk management, profitability, ratification of the Kyoto protocol and exposure to social and political pressure are playing an important role in enhancing the disclosure about risks and opportunities.

With regard to emissions and verification and trading disclosures, the Kyoto protocol is still significant with these disclosures. In addition, profitability is significant with the disclosure about verification and trading activities. Finally, for the carbon performance and governance disclosures, firms' size is significant with *P*-value of 0.021 and 0.015 respectively. This result can be interpreted as that larger firms are likely to have resources to engage in carbon performance and governance activities, and ultimately to produce detailed information about these activities (for more details about these activities see appendix 1).

In respect of the second analysis, Table 5.4 indicates that all carbon risk management categories are positively and significantly associated with their matched carbon disclosure categories except for the carbon emissions category. For carbon risk management this is the emissions intensity as a part of the total carbon risk management score. Carbon emissions disclosure constitutes the disclosure of scopes 1, 2, and 3 of carbon emissions, and the methodologies that are employed to calculate these scopes (for more details see appendix 1, section 2 emissions accounting). This result suggests that firms' management are more likely to disclose high quality information about various carbon risk management activities rather than focusing on carbon emission accounting information (historical). Since emissions intensity represents the actual emissions, the disclosure of these emissions cannot be considered as high or low disclosure quality.

Two possible interpretations could be explaining this result. First, carbon emission information is disclosed to the government's agents and made publicly available (for more details see chapter 1, section 1.4). That is, managers may prefer to disclose more information about their future risk management activities rather than release information about their historical carbon level in sustainability reports. Second, as can be seen from Table 5.4 (Panel B), carbon legitimacy proxy (J-Fcoe) is positively and significantly associated with carbon emission disclosure (*P*-value = 0.017). This association indicates that social and political pressure (as well as KYOTO and SIZE) plays a crucial role in determining carbon emissions disclosure. This result is consistent with studies that support legitimacy theory based on merely taking into account emission levels disclosure (Cho & Patten 2007; Cormier, Ledoux & Magnan 2009; Dragomir 2010; Patten 2002).

In conclusion, firms with superior carbon risk management practices tend to provide high quality (hard) information about these activities that would be difficult to imitate by inferior firms. This information does not include emissions intensity since it represents the actual emissions rather than the ability of a firm to deal with them. That is, the amount of carbon emissions per se does not capture the quality of a firm in dealing with the risks associated with these emissions. Hence, emissions intensity does not appear to be a driver of carbon disclosure as suggested by socio-political theories. Instead, the a firm's efficiency and effectiveness in dealing and managing carbon and climate change issues play crucial role in enhancing carbon disclosure quality. These results, therefore, question the credibility of studies that disregard the performance to deal with emissions, and studies that incorporate inadequate performance proxy such as merely toxic releases. Previous results presented in sections 5.1.2 and 5.1.4 can be further explored by examining within sectors; hence, regression analysis is conducted within each industry.

5.2.5 Intra-industry regression results

A further analysis within industries is conducted. The compelling reason for this analysis is that carbon disclosure is expected to differ between industries since firms in different sectors have different incentives to disclose such information. Thus, generalising the results based on pooled data is inconclusive. This analysis is conducted by running regression models 3 and 4 within each GISC industry classification separately. Given that regression models are run in each sector, there is no need to control for the industry specific effects. In addition, D-FIN and LEV variables are re-included to all industries except for the financials sector.

Table 5.3 Regression results based on disclosure categories (Full sample)

$$\text{Risk\&opp}_{i,t} = \gamma_0 + \gamma_1\text{CRM}_{i,t} + \gamma_2\text{ROE}_{i,t} + \gamma_3\text{S-FIN}_{i,t+1} + \gamma_4\text{SIZE}_{i,t} + \gamma_5\text{KYOTO}_{i,t} + \gamma_6\text{J-Fcoe}_{i,t} + \gamma_7\text{S-VOLAT}_{i,t} + \gamma_8\text{TOBIN'SQ}_{i,t} + \gamma_9\sum\text{IND}_{i,t} + \varepsilon_{i,t}$$

$$\text{Emissions}_{i,t} = \gamma_0 + \gamma_1\text{CRM}_{i,t} + \gamma_2\text{ROE}_{i,t} + \gamma_3\text{S-FIN}_{i,t+1} + \gamma_4\text{SIZE}_{i,t} + \gamma_5\text{KYOTO}_{i,t} + \gamma_6\text{J-Fcoe}_{i,t} + \gamma_7\text{S-VOLAT}_{i,t} + \gamma_8\text{TOBIN'SQ}_{i,t} + \gamma_9\sum\text{IND}_{i,t} + \varepsilon_{i,t}$$

$$\text{Verification \&Trading}_{i,t} = \gamma_0 + \gamma_1\text{CRM}_{i,t} + \gamma_2\text{ROE}_{i,t} + \gamma_3\text{S-FIN}_{i,t+1} + \gamma_4\text{SIZE}_{i,t} + \gamma_5\text{KYOTO}_{i,t} + \gamma_6\text{J-Fcoe}_{i,t} + \gamma_7\text{S-VOLAT}_{i,t} + \gamma_8\text{TOBIN'SQ}_{i,t} + \gamma_9\sum\text{IND}_{i,t} + \varepsilon_{i,t}$$

$$\text{Performance}_{i,t} = \gamma_0 + \gamma_1\text{CRM}_{i,t} + \gamma_2\text{ROE}_{i,t} + \gamma_3\text{S-FIN}_{i,t+1} + \gamma_4\text{SIZE}_{i,t} + \gamma_5\text{KYOTO}_{i,t} + \gamma_6\text{J-Fcoe}_{i,t} + \gamma_7\text{S-VOLAT}_{i,t} + \gamma_8\text{TOBIN'SQ}_{i,t} + \gamma_9\sum\text{IND}_{i,t} + \varepsilon_{i,t}$$

$$\text{Governance}_{i,t} = \gamma_0 + \gamma_1\text{CRM}_{i,t} + \gamma_2\text{ROE}_{i,t} + \gamma_3\text{S-FIN}_{i,t+1} + \gamma_4\text{SIZE}_{i,t} + \gamma_5\text{KYOTO}_{i,t} + \gamma_6\text{J-Fcoe}_{i,t} + \gamma_7\text{S-VOLAT}_{i,t} + \gamma_8\text{TOBIN'SQ}_{i,t} + \gamma_9\sum\text{IND}_{i,t} + \varepsilon_{i,t}$$

	CRM	ROE	S-FIN	SIZE	KYOTO	J-Fcoe	S-VOLAT	TOBIN's Q	Adj.R^2	F-statistic
Risks & Opportunities	0.061[a] 0.000**[b]	3.755 0.037*	-0.494 0.447	-0.334 0.534	1.687 0.000**	0.858 0.029*	0.781 0.572	-0.724 0.065	0.283	7.637**
Emissions	0.155 0.000**	1.634 0.610	-0.802 0.490	0.585 0.542	4.325 0.000**	0.770 0.272	-0.022 0.993	-0.167 0.812	0.354	10.225**
Verification &Trading	0.079 0.000**	5.371 0.014*	-0.307 0.698	1.046 0.111	3.813 0.000**	0.631 0.188	0.233 0.890	-0.011 0.982	0.398	12.142**
Performance	0.137 0.000**	1.985 0.322	-0.341 0.638	1.395 0.021*	1.596 0.002*	0.525 0.231	-2.100 0.174	-0.135 0.757	0.431	13.738**
Governance	0.071 0.000**	2.011 0.154	0.294 0.566	1.036 0.015*	0.897 0.011*	0.257 0.404	-1.209 0.266	-0.607 0.050	0.363	10.581**

[a] Unstandardised coefficients. [b] *P*-values. **,* represent significant levels at 0.001 and 0.05 respectively

Variables definition: CDIS1 is the carbon disclosure scores obtained from CDLI 2009; CDIS2 is the carbon disclosure scores based on annual and sustainability reports and corporate websites; CRM is the carbon risk management scores; ROE is the ratio of net profit to shareholders' equity. S-FIN is a binary variables that eqal1 if shares capital raised in 2010, 0 otherwise; SIZE is the natural logarithm of total sales; IND is a binary variable for high and low polluting sectors; KYOTO is a binary variable for firms from countries that ratified and did not ratify the Kyoto protocol. J-Fcoe is the Janis-Fadner coefficient; S-VOLAT is the twelve months' volatility of stock's returns; TOBIN'S Q is the sum of market value of common equity, book value of preferred stock and book value of long term debt and current liability divided by book value of total assets. IND is a series of nine industry dummy variables: 1 = a company was from a particular industry group and 0 = otherwise. The Telecommunications sector is excluded as reference sector.

Table 5.4 Regression results based on disaggregated carbon disclosure and risk management scores (Full sample)

Panel A: Regression results based on risks & opportunities disclosure and risk management										
	Risks & Opportunities risk management	ROE	S-FIN	SIZE	KYOTO	J-Fcoe	S-VOLAT	TOBIN's Q	Adj.R^2	F-statistic
Risks & Opportunities disclosure	0.192[a] 0.000**[b]	9.949 0.081	-1.419 0.491	0.421 0.795	5.538 0.000**	2.148 0.086	0.734 0.867	-1.837 0.141	0.351	10.111**
Panel B: Regression results based on emissions accounting disclosure and risk management										
	Emissions intensity	ROE	S-FIN	SIZE	KYOTO	J-Fcoe	S-VOLAT	TOBIN's Q	Adj.R^2	F-statistic
Emissions disclosure	0.027 0.308	8.018 0.246	-0.525 0.835	4.465 0.030*	10.653 0.000**	3.542 0.017*	-0.377 0.944	-0.561 0.712	0.232	6.069**
Panel C: Regression results based on verification &trading disclosure and risk management										
	Verification &Trading risk management	ROE	S-FIN	SIZE	KYOTO	J-Fcoe	S-VOLAT	TOBIN's Q	Adj.R^2	F-statistic
Verification &Trading disclosure	0.035 0.009*	16.492 0.010*	-0.230 0.921	4.330 0.019*	12.159 0.000**	2.991 0.030*	-2.161 0.662	-0.406 0.772	0.328	9.214**
Panel D: Regression results based on performance disclosure and risk management										
	Performance risk management	ROE	S-FIN	SIZE	KYOTO	J-Fcoe	S-VOLAT	TOBIN's Q	Adj.R^2	F-statistic
Performance disclosure	0.334 0.000**	6.766 0.162	-0.316 0.857	4.959 0.001*	4.068 0.001*	1.752 0.094	-6.102 0.103	-0.116 0.913	0.566	22.966**
Panel E: Regression results based on governance disclosure and risk management										
	Governance risk management	ROE	S-FIN	SIZE	KYOTO	J-Fcoe	S-VOLAT	TOBIN's Q	Adj.R^2	F-statistic
Governance disclosure	0.380 0.000**	11.008 0.261	2.106 0.552	9.412 0.001*	5.199 0.034*	1.896 0.371	-4.298 0.570	-3.766 0.079	0.423	13.358**

[a] Unstandardised coefficients. [b] *P*-values. **,* represent significant levels at 0.001 and 0.05 respectively.

Table 5.5 presents the regression results within industry sectors based on the GISC classification. Relating to CDIS1 proxy, six sectors exhibit positive and significant association between CDIS1 and CRM. These are the industrials, consumer staples, financials, telecommunications, utilities, and information technology sectors. However, four sectors show insignificant association. These are the consumer discretionary, energy, materials, and health care sectors. Interestingly, no other driver for carbon disclosure is observed within the consumer discretionary, energy and health care sectors. However, the materials sector shows that profitability (ROE), share issues (S-FIN) and leverage (LEV) are drivers of carbon disclosure rather than carbon risk management.

With regard to CDIS2, a significant positive association with CRM is also observed within all sectors except for the consumer staples, financials, and materials sectors. For the materials sector, this is a surprising result since this sector is considered as an intensive carbon industry, which may be subject to more carbon restrictions and social scrutiny. However, similar to the CDIS1 results, the profitability factor is significantly associated with CDIS2, indicating that profitability rather than carbon risk management drives carbon disclosure for the materials sector's firms. For the financials sector, size, the Kyoto protocol and carbon legitimacy proxy are positively and significantly associated with CDIS2. This result suggests that the firm's size, ratification of the Kyoto protocol as well as exposure to social and political pressure are more powerful than carbon risk management determinants of carbon disclosure for financials' firms.

To sum up results across the two disclosure measures, the positive relationship between carbon risk management and carbon disclosure is observed with two exceptions. First, this positive association is not found in the materials sector. Interestingly, the profitability factor drives carbon disclosure through the two disclosure channels instead of carbon risk management. Additionally, share issuance and leverage appear as other determinants of carbon disclosure through the CDP. Second, carbon risk management is positively associated with only carbon disclosure via CDP within the consumer staples and financials sectors. In contrast, it turns to be positively associated with only carbon disclosure via sustainability reports within the consumer discretionary, health care, and energy sectors.

It should be noted that previous results may not generalise to firms from all countries due to the possible existence of cultural and legal contextual differences. Therefore, further analysis based on country affiliation is presented in the next section.

5.2.6 Intra-country regression results

Table 5.6 displays the regression results for the relationship between carbon risk management and carbon disclosure based on country of incorporation. All regression analyses performed are similar to models 3 and 4 with the KYOTO variable eliminated since this variable is defined by country. However, this variable is incorporated in North America analysis since Canada has ratified this protocol whereas USA has not. Additionally, no regression analysis is conducted within the Others group since it comprises only six firms.

Table 5.5 Intra-industry regression results (GISC classification)

		CRM	ROE	D-FIN	S-FIN	LEV	SIZE	KYOTO	J-Fcoe	S-VOLAT	TOBIN's Q	Adj.R^2	F-statistic
Industrials No. 24	CDIS 1	0.687[a] 0.002**[b]	35.116 0.165	-5.023 0.420	-	-2.921 0.903	-8.328 0.385	-2.444 0.737	-0.476 0.954	16.974 0.459	-13.313 0.143	0.379	2.561
	CDIS 2	0.418 0.018*	-7.299 0.726	4.682 0.379	-	-23.967 0.251	-1.494 0.853	7.699 0.226	-7.413 0.303	-7.379 0.704	-5.139 0.494	0.368	2.485
Consumer Discretionary No. 21	CDIS 1	-0.053 0.812	7.087 0.929	34.014 0.208	13.642 0.514	5.939 0.875	-20.698 0.199	33.266 0.065	-5.210 0.556	179.823 0.125	-3.214 0.742	0.429	2.427
	CDIS 2	0.433 0.002*	59.740 0.126	-0.522 0.965	-0.275 0.977	-34.701 0.069	17.891 0.028*	-0.008 0.999	8.696 0.053	24.669 0.624	-1.468 0.743	0.841	11.040**
Consumer Staples No. 31	CDIS 1	0.409 0.014*	7.506 0.741	-4.705 0.359	-1.762 0.894	-10.035 0.662	12.539 0.033*	-2.501 0.605	1.625 0.697	-31.740 0.200	5.102 0.273	0.294	2.252
	CDIS 2	0.109 0.254	6.709 0.630	-4.643 0.146	-3.804 0.639	-4.917 0.726	4.203 0.225	9.042 0.006*	0.401 0.875	-27.678 0.073	4.760 0.101	0.369	2.752**
Energy No. 30	CDIS 1	0.333 0.093	12.541 0.841	-0.704 0.922	22.189 0.113	33.922 0.410	-2.416 0.789	-5.263 0.519	-5.881 0.377	-2.706 0.932	-7.707 0.340	0.085	1.269
	CDIS 2	0.400 0.001**	29.344 0.391	-2.941 0.456	-1.453 0.844	-15.040 0.500	-4.768 0.337	4.709 0.293	-0.363 0.919	26.944 0.128	-5.903 0.184	0.472	3.587**
Financials No. 56	CDIS 1	0.308 0.015*	8.538 0.656	-	2.291 0.547	--	3.404 0.535	-5.070 0.352	1.486 0.667	0.652 0.943	5.856 0.224	0.118	1.918
	CDIS 2	0.055 0.494	-14.076 0.269	-	2.110 0.402	--	9.031 0.016*	9.075 0.014*	4.962 0.033*	-3.720 0.536	-2.022 0.522	0.527	8.656**
Materials No. 26	CDIS 1	0.138 0.585	80.813 0.045*	0.897 0.883	25.413 0.021*	77.050 0.027*	13.250 0.227	-4.270 0.556	-5.938 0.353	-28.430 0.303	-1.484 0.784	0.345	2.317
	CDIS 2	0.211 0.160	50.615 0.032*	3.985 0.270	3.190 0.583	34.669 0.076	4.341 0.486	4.133 0.330	-1.501 0.681	-11.391 0.471	-4.231 0.188	0.565	4.249**
Telecommunications No. 19	CDIS 1	0.416 0.037*	-15.782 0.417	-14.947 0.131	3.328 0.838	17.455 0.548	-15.314 0.242	2.267 0.792	6.145 0.252	4.836 0.905	10.116 0.462	0.333	1.897
	CDIS 2	0.306 0.028*	14.057 0.298	-7.267 0.267	16.753 0.159	1.105 0.955	-1.643 0.848	3.767 0.528	3.147 0.383	-21.878 0.440	-1.614 0.862	0.655	4.412**
Utilities No. 32	CDIS 1	0.377 0.001**	4.529 0.863	-6.404 0.064	-3.141 0.617	-45.778 0.020*	1.088 0.847	-0.951 0.811	10.717 0.014*	5.778 0.728	7.659 0.499	0.656	6.925**
	CDIS 2	0.297 0.014*	-5.938 0.837	-4.916 0.190	2.751 0.692	-1.864 0.927	10.395 0.106	6.339 0.160	0.673 0.881	5.324 0.772	16.050 0.206	0.491	3.992**

Continued Table 5.5 Intra-industry regression results

Health Care No. 23	CDIS 1	0.349 0.213	-7.427 0.834	3.655 0.689	-16.393 0.354	0.838 0.984	-8.284 0.519	-0.953 0.916	12.823 0.168	47.173 0.369	-5.563 0.605	-0.006	0.989
	CDIS 2	0.289 0.023*	19.818 0.192	4.889 0.210	-12.211 0.108	24.725 0.172	-10.959 0.057	9.680 0.023*	7.577 0.058	-7.173 0.735	-10.127 0.039*	0.710	5.885**
Information Technology No. 26	CDIS 1	0.584 0.002*	-12.221 0.551	0.321 0.956	0.453 0.970	-29.573 0.577	13.947 0.030*	-1.805 0.734	-1.470 0.778	-11.828 0.672	3.399 0.378	0.465	3.171**
	CDIS 2	0.658 0.000**	-24.299 0.152	-5.267 0.268	-0.185 0.985	-64.361 0.142	6.394 0.157	1.436 0.736	7.204 0.100	-47.066 0.049*	0.679 0.824	0.636	5.375**

a) [a] Unstandardised coefficients. [b] *P*-values. - These variables cannot be computed as they are constant. -- missing values. **,* represent significant levels at 0.001 and 0.05 respectively.

Consistent with the previous analyses, the significant and positive association between CRM and CDIS exists with the exception of the UK. This result is consistent with the Brammer and Pavelin's (2006) finding that environmental performance has no role in enhancing environmental disclosure of UK firms. This insignificant result for the UK might be attributed to several reasons. For instance, UK firms disseminate social responsibility information in order to comply with stakeholders' calls (Idowu & Papasolomou 2007; Kolk 2003). Although carbon legitimacy proxy is not significant in Table 5.6, size and Tobin's q appear to derive carbon disclosure via CDP. In addition, carbon reduction schemes might be another driver for carbon disclosure. Large UK firms are regulated by Europe Union Emissions Trading Scheme (EU ETS) and have the pending Carbon Reduction Commitment (CRC) scheme[6].

When the industry effect is considered in addition to country, the following results are observed. In North America, CDIS1 is insignificant for all sectors, whereas the consumer discretionary, energy and materials sectors are significant for CDIS2. For EU, CDIS1 is not significant for all sectors, while materials and utilities are significant for CDIS2. Finally, for the Asia & Pacific sectors are not significant with both CDIS1 and CDIS2. These results indicate that firms from carbon intensive sectors form North America and EU are more likely to release carbon relevant information via their corporate reporting channels rather than CDP.

[6] For more details about this scheme see chapter 1.

5.2.7 Robustness test for socio-political theories and other disclosure determinants

In this analysis, carbon risk management is excluded from the regression analysis to make comparison with prior studies that have not incorporated carbon risk management in their analyses (e.g, Freedman & Jaggi 2005, 2011; Prado-Lorenzo et al. 2009; Stanny & Ely 2008). Table 5.7 shows that carbon disclosure via CDP (CDIS1) is positively and significantly associated with firm size, and the carbon legitimacy proxy (J-Fcoe) with *P*-values of 0.005 and 0.004 respectively. These results indicate that in the absence of controlling for carbon risk management, firms' size and social and political pressure that made via media channels play an important role in enhancing carbon disclosure via CDP.

In addition, Table 5.7 shows that carbon disclosure via sustainability reports (CDIS2) has a positive and significant relationship with profitability (ROE), size, the ratification of Kyoto, and carbon legitimacy proxy (J-Fcoe). These results suggest that larger firms with high earnings tend to make more carbon disclosures via their sustainability reports than smaller firms with lower profitability. Moreover, firms with higher exposure to media news (as measured by the carbon legitimacy proxy J-Fcoe) are more likely to make carbon disclosures to legitimise their activities. Once again, these factors appear as key drivers of carbon disclosure in the absence of controlling for carbon risk management.

The difference in results for the carbon legitimacy proxy (or media exposure factor) depending on the inclusion of the carbon risk management variable, warrants further discussion. One interpretation of these results is that carbon risk management

dominates other factors in explaining the carbon disclosure practices. Indeed, once carbon risk management is included in the analyses, carbon legitimacy proxy becomes insignificant. These results may, to some extent, explain differences in results found in previous studies since many of these studies have not incorporated carbon risk management (environmental performance) in their analyses, or have employed inappropriate proxy for environmental performance.

5.2.8 Summary

Previous sections report several tests for hypothesis 1, which predicts the existence of positive relationship between carbon risk management and carbon disclosure. Regression results provide strong support for the existence of such a positive relationship. Hence, there is strong evidence to support the conjecture of economic-based disclosure theories (signalling and voluntary disclosure theories). Firms' propensity to release credible and high quality carbon information via CDP and sustainability reports is significantly and positively associated with carbon risk management practices. Firms that are responding to and dealing well with carbon and climate change risks and opportunities disclose high quality information about their strategies and policies. Indeed, these firms convey this information to signal their performance related to climate change to differentiate themselves from poor performers.

Table 5.6 Regression results by country

		CRM	ROE	S-FIN	SIZE	KYOTO	**J-Fcoe**	**S-VOLAT**	**TOBIN's Q**	Adj.R^2	F statistic
North America No. 131	CDIS 1	0.421[a] 0.000**[b]	-0.158 0.989	5.554 0.176	-1.629 0.589	-4.616 0.214	0.138 0.955	-1.401 0.885	0.306 0.883	0.251	3.540**
	CDIS 2	0.293 0.000**	1.197 0.886	-2.785 0.354	2.861 0.197	2.455 0.366	1.401 0.431	-2.086 0.769	-1.410 0.356	0.350	5.093**
EU No. 78	CDIS 1	0.554 0.000**	-2.723 0.811	-1.381 0.722	-0.172 0.962	-*	0.592 0.824	-1.301 0.891	0.800 0.763	0.407	4.308**
	CDIS 2	0.393 0.000**	3.246 0.687	-2.358 0.392	0.956 0.705	-*	2.035 0.282	-7.857 0.245	0.662 0.724	0.511	6.028**
UK No. 27	CDIS 1	0.137 0.520	-11.451 0.478	2.143 0.657	24.649 0.015*	-*	5.701 0.207	17.922 0.328	17.239 0.015*	0.557	3.335*
	CDIS 2	-0.067 0.646	15.170 0.184	6.442 0.070	3.720 0.545	-*	-2.250 0.459	-2.250 0.335	8.279 0.072	0.423	2.359
Asia & Pacific No. 46	CDIS 1	0.292 0.026*	54.312 0.051	-8.082 0.293	-1.909 0.718	-*	1.842 0.568	37.892 0.077	0.759 0.895	0.443	3.236*
	CDIS 2	0.296 0.003*	48.053 0.022*	2.281 0.687	-0.974 0.804	-*	2.068 0.389	-3.314 0.830	-5.455 0.205	0.335	2.418*

[a] Unstandardised coefficients. [b] *P*-values. **,* represent significant levels at 0.001 and 0.05 respectively.

Variables definition: CDIS1 is the carbon disclosure scores obtained from CDLI 2009; CDIS2 is the carbon disclosure scores based on annual and sustainability reports and corporate websites; CRM is the carbon risk management scores; ROE is the ratio of net profit to shareholders' equity. D-FIN and S-FIN are binary variables that eqal1 if debt or shares capital raised in 2010, 0 otherwise; LEV is the ratio of total debt to total assets; SIZE is the natural logarithm of total sales; KYOTO is a binary variable for firms from countries that ratified and did not ratify the Kyoto protocol. J-Fcoe is the Janis-Fadner coefficient; S-VOLAT is the twelve months' volatility of stock's returns; TOBIN'S Q is the sum of market value of common equity, book value of preferred stock and book value of long term debt and current liability divided by book value of total assets.

Table 5.7 Regression results for the carbon disclosure determinants (full sample)

$CDIS1_{i,\,t} = \alpha_0 + \alpha_1 ROE_{\,i,t} + \alpha_2 S\text{-}FIN_{i,t+1} + \alpha_3 SIZE_{\,i,t} + \alpha_4 KYOTO_{i,t} + \alpha_5 J\text{-}Fcoe_{i,t} + \alpha_6 S\text{-}VOLAT_{\,i,t} + \alpha_7 TOBIN'SQ_{\,i,t} + \gamma_8 \sum IND + \varepsilon_{\,i,t}$

$CDIS1_{i,\,t} = \alpha_0 + \alpha_1 ROE_{\,i,t} + \alpha_2 S\text{-}FIN_{i,t+1} + \alpha_3 SIZE_{\,i,t} + \alpha_4 KYOTO_{i,t} + \alpha_5 J\text{-}Fcoe_{i,t} + \alpha_6 S\text{-}VOLAT_{\,i,t} + \alpha_7 TOBIN'SQ_{\,i,t} + \gamma_8 \sum IND + \varepsilon_{\,i,t}$

variable	Regression results based on CDP disclosure (CDIS1, model 3)			Regression results based on sustainability reports disclosures (CDIS2, model 4)		
	Coefficient	**t-value**	***P*- value**	**Coefficient**	**t-value**	***P*- value**
Intercept	4.985	0.313	0.755	-35.514	-3.050	0.003
ROE	11.927	1.656	0.099	13.372	2.542	0.012*
S-FIN	3.193	1.220	0.224	0.284	0.149	0.882
SIZE	5.809	2.816	0.005*	6.191	4.110	0.000**
KYOTO	0.341	0.191	0.849	9.318	7.157	0.000**
J-Fcoe	4.482	2.915	0.004*	4.151	3.697	0.000**
S-VOLAT	4.999	0.896	0.371	-3.140	-0.771	0.441
TOBON's Q	0.991	0.626	0.532	-1.118	-0.966	0.335
Industrials	6.171	1.510	0.132	6.056	2.029	0.043*
Consumer Discretionary	5.583	1.289	0.199	9.809	3.100	0.002*
Consumer Staples	5.744	1.465	0.144	5.704	1.993	0.047*
Energy	9.138	2.254	0.025*	9.794	3.308	0.001*
Financials	11.457	2.795	0.006*	5.894	1.969	0.050
Materials	10.830	2.519	0.012*	15.238	4.853	0.000**
Utilities	12.208	3.148	0.002*	12.156	4.293	0.000**
Health Care	10.421	2.481	0.014*	4.945	1.612	0.108
Information Technology	9.125	2.172	0.031*	9.270	3.022	0.003*
Adj.R^2	0.087			0.331		
F-statistic	2.701*			9.859**		

**,* represent significant levels at 0.001 and 0.05 respectively

Variables definition: CDIS1 is the carbon disclosure scores obtained from CDLI 2009; CDIS2 is the carbon disclosure scores based on annual and sustainability reports and corporate websites; CRM is the carbon risk management scores; ROE is the ratio of net profit to shareholders' equity. S-FIN is binary variables that eqal1 if shares capital raised in 2010, 0 otherwise; SIZE is the natural logarithm of total sales; KYOTO is a binary variable for firms from countries that ratified and did not ratify the Kyoto protocol. J-Fcoe is the Janis-Fadner coefficient; S-VOLAT is the twelve months' volatility of stock's returns; TOBIN'S Q is the sum of market value of common equity, book value of preferred stock and book value of long term debt and current liability divided by book value of total assets. IND is a series of nine industry dummy variables: 1 = a company was from a particular industry group and 0 = otherwise. The Telecommunications sector is excluded as reference sector. VIF values are all lower than 3.0 except for the Financials industry with values of 4.486 in both of CDIS1and CDIS2 models.

In addition, firms' profitability and the ratification of the Kyoto protocol are found to be related to carbon disclosure when these firms choose to disclose such information via sustainability reports. These results are robust to sensitivity tests. Interestingly, there are some differences in results when carbon disclosure components, intra-country and industry analyses are considered. These additional results indicate that that this relationship varies across carbon disclosure types, contexts, and sectors.

Previous sections discuss the first construct of this study which is the relationship between carbon risk management and disclosure. Given that this study is investigating the interrelationships between carbon risk management, carbon disclosure and stock market indicators, the next section considers the second construct which is the relationship between the ex-ante, carbon risk management and disclosure activities.

5.3 Empirical results for the Relationship between carbon disclosure, carbon risk management and the ex-ante cost of equity capital

This section explains the results obtained from examining the associations between carbon disclosure proxies (CDIS1 and CDIS2), carbon risk management (CRM) and the ex-ante cost of equity capital E (Ke). These associations are hypothesised in H2a and H3a (see chapter 2) as follows:

H2a - There is a negative relationship between the quality of carbon disclosure and the ex-ante cost of equity capital.

H3a -There is a negative relationship between carbon risk management and the ex-ante cost of equity capital.

These hypotheses are tested by running regression models 5 and 6, which are developed in chapter 3.

Table 5.8 Correlation matrix: (Pearson above diagonal, Spearman below)

$E(Ke)_{i,t} = \beta_0+\beta_1 CDIS1_{i,t}+\beta_2 CRM_{i,t}+\beta_3 BETA_{i,t}+\beta_4 BtoP_{i,t}+\beta_5 SIZE_{i,t}+ \beta_6 \sum IND_{i,t}+\varepsilon_{i,t}$

$E(Ke)_{i,t}= \psi_0+\psi_1 CDIS2_{i,t}+\psi_2 CRM_{i,t}+\psi_3 BETA_{i,t}+\psi_4 BtoP_{i,t}+\psi_5 SIZE_{i,t}+\psi_6 \sum IND_{i,t}+ \varepsilon_{i,t}$

Panel A: Correlation coefficients based on CDP disclosure						
	E(Ke)	**CDIS1**	**CRM**	**BETA**	**BtoP**	**SIZE**
E(Ke)	1	-0.002	0.013	0.468**	0.389**	0.122*
CDIS1 (-)	-0.007	1	0.527**	0.135**	-0.023	0.171**
CRM (-)	-0.003	0.535**	1	0.074	0.055	0.351**
BETA (+)	0.456**	0.142*	0.102	1	0.486**	0.107
BtoP (+)	0.213**	-0.031	0.076	0.369**	1	0.186**
SIZE (-)	0.144**	0.163**	0.324**	0.118*	0.197**	1
Panel B: Correlation coefficients based on annual and sustainability reports and corporate websites disclosures						
	E(Ke)	**CDIS2**	**CRM**	**BETA**	**BtoP**	**SIZE**
E(Ke)	1	0.043	0.013	0.468**	0.389**	0.122*
CDIS2 (-)	0.029	1	0.625**	-0.018	0.059	0.312**
CRM (-)	-0.003	0.631**	1	0.074	0.055	0.351**
BETA (+)	0.456**	0.035	0.102	1	0.486**	0.107
BtoP (+)	0.213**	0.085	0.076	0.369**	1	0.186**
SIZE (-)	0.144**	0.305**	0.324**	0.118*	0.197**	1

**,* represent significant levels at 0.01 and 0.05 (two-tailed) respectively.

Variables definition: **E (Ke)** is the estimated ex-ante cost of equity capital as measured by PEG ratio method; **CDIS1** is the carbon disclosure scores obtained from CDLI 2009; **CDIS2** is the carbon disclosure scores based on annual and sustainability reports and corporate websites; **CRM** is the carbon risk management scores; **BETA** is the firm's systematic risk; **BtoP** is the book to price ratio; **SIZE** is the natural logarithm of total sales. IND is a series of nine industry dummy variables: 1 = a company was from a particular industry group and 0 = otherwise. The Telecommunications sector is excluded as reference sector.

5.3.1 Correlation results for hypotheses 2a and 3a

Table 5.8 (Panels A and B) presents the Pearson and Spearman correlations between carbon disclosure proxies and the ex-ante cost of equity capital. Panel A presents the correlation among E (Ke), CDIS1, CRM, and control variables. It can be seen that

both Pearson and Spearman correlations show no association between the E (Ke) and CDIS1. This result provides prima facia evidence that investors do not price carbon disclosure via CDP. This in turn suggests rejecting the assumption of hypothesis 2a.

Panel B of Table 5.8 shows similar results to those reported in Panel A. CDIS2 is not correlated with E (Ke). The results in Panels A and B indicate that carbon disclosures that are made via CDP and sustainability reports are not priced by investors.

With regard to hypothesis 3a, Panels A and B of Table 5.8 show that CRM is not correlated with the E (Ke). This result is consistent for both Pearson and Spearman correlations, and does not support hypothesis 3a, which predicts a negative association between carbon risk management and the ex-ante cost of equity capital.

For the control variables, BETA and BtoP are positively and significantly associated with the E (Ke), whereas SIZE shows contrasting results to the prior literature. While previous studies find that the ex-ante cost of equity capital decreases with a firm's size, Pearson and Spearman correlations show that size is positively and significantly associated with the ex-ante cost of equity capital. This conflicting result may be attributed to all firms in the sample being large. To assess the validity of this result, two alternative measures of size are incorporated in the analysis. These are total assets and market value. However, similar results to those when total sales is employed are observed. Finally, consistent with the results obtained from testing hypothesis 1, a positive and significant association between CDIS1 and carbon risk management (CRM) is observed.

5.3.2 Regression results for hypotheses 2a and 3a

Table 5.9 exhibits the regression results for the tests of hypotheses 2a and 3a. These hypotheses predict a negative relationship between carbon disclosure and carbon risk management and the ex-ante cost of equity capital. The first three columns of Table 5.9 report the results from regressing E (Ke) on CDIS1, CRM and other control variables, whereas, the second three columns report the results based on CDIS2.

With regard to hypothesis 2a, the results obtained from regressing E (Ke) on CDIS1 and CDIS2 are consistent. For the CDIS1 specification, the regression test has an adjusted R^2 of 0.273, F statistic of 8.689 and a P-value of 0.000. The explanatory power of this model is reasonable compared with previous research. Clarkson et al. (2010) employ similar cost of equity capital proxy (rPEG of Easton (2004)) using pooled data from USA in 2003 and 2006, and their R^2 ranges from 0.1526 to 0.1918. It can be seen that CDIS1 is not statistically significant at the 0.05 or 0.001 levels; indicating that carbon disclosure via CDP has no impact on the ex-ante cost of equity capital.

In addition, when using CDIS2 scores, the explanatory power of regression model is slightly higher with an adjusted R^2 of 0.275, F statistic of 8.745 and a P-value of 0.000. However, the results show no statistically significant association between the ex-ante cost of equity capital and carbon disclosure via sustainability reports. Hence, these results reject hypothesis 2a that high quality of carbon disclosure leads to a reduction of the ex-ante cost of equity capital.

Table 5.9 Regression results for the relationship between ex-ante cost of equity capital, carbon disclosure and carbon risk management (full sample)

$$E(Ke)_{i,t} = \beta_0+\beta_1 CDIS1_{i,t}+\beta_2 CRM_{i,t}+\beta_3 BETA_{i,t}+\beta_4 BtoP_{i,t}+\beta_5 SIZE_{i,t}+ \beta_6 \sum IND_{i,t}+\varepsilon_{i,t}$$

$$E(Ke)_{i,t} = \psi_0+\psi_1 CDIS2_{i,t}+\psi_2 CRM_{i,t}+\psi_3 BETA_{i,t}+\psi_4 BtoP_{i,t}+\psi_5 SIZE_{i,t}+\psi_6 \sum IND_{i,t}+ \varepsilon_{i,t}$$

variable	**Regression results based on CDP disclosure (CDIS1)**			**Regression results based on sustainability reports disclosures (CDIS2)**		
	Coefficient	**t-value**	***P*- value**	**Coefficient**	**t-value**	***P*- value**
Intercept	0.018	0.179	0.858	0.009	0.227	0.821
CDIS1	-8.79E-5	-0.443	0.658			
CDIS2				0.000	0.865	0.388
CRM	0.000	-0.871	0.384	0.000	-1.530	0.127
BETA	0.022	3.440	0.001**	0.022	3.486	0.001**
BtoP	0.029	4.257	0.000**	0.029	4.371	0.000**
SIZE	0.007	1.164	0.245	0.006	1.006	0.315
Industrials	0.011	0.935	0.351	0.011	0.894	0.372
Consumer Discretionary	0.018	1.432	0.153	0.016	1.326	0.186
Consumer Staples	0.018	1.617	0.107	0.018	1.606	0.109
Energy	0.019	1.657	0.099	0.018	1.519	0.130
Financials	0.010	0.817	0.415	0.009	0.752	0.452
Materials	0.038	3.045	0.003*	0.036	2.860	0.005*
Utilities	-0.002	-0.211	0.833	-0.004	-0.379	0.705
Health Care	0.013	1.143	0.254	0.013	1.100	0.272
Information Technology	0.025	2.066	0.040*	0.024	2.042	0.042*
Adj.R^2	0.273			0.275		
F-statistic	8.689**			8.745**		

Dependent variable is ex-ante cost of equity capital E (Ke). **,* represent significant levels at 0.001 and 0.05 respectively.

Variables definitions: **E (Ke)** is the estimated ex-ante cost of equity capital as measured by PEG ratio method; **CDIS1** is the carbon disclosure scores obtained from CDLI 2009; **CDIS2** is the carbon disclosure scores based on annual and sustainability reports and corporate websites; **CRM** is the carbon risk management scores; **BETA** is the firm's systematic risk; **BtoP** is the book to price ratio; **SIZE** is the natural logarithm of total sales; **IND** is a series of nine industry dummy variables: 1 = a company is from a particular industry group and 0 = otherwise. The Financials sector is excluded as reference sector. VIF values are all lower than 3.0 except for the Financials industry with values of 5.171 in CDIS1 model, and 5.139 in CDIS2 model.

These findings are consistent with Clarkson et al. (2010) and Dejean and Martinez (2009) who did not observe such association between environmental disclosure and the ex-ante cost of equity capital. Furthermore, these results confirm the Haigh and Shapiro's (2010) (cited in DEFRA (2010)) findings that institutional investors from Europe, North America, Japan and Australia do not use carbon and climate change data to guide portfolio allocation.

With respect to carbon risk management, Table 5.9 also presents the results of the test of hypothesis 3a. This hypothesis predicts a negative relationship between carbon risk management and the ex-ante cost of equity capital. The regression results show that CRM is not significant, indicating that there is no relationship between E (Ke) and CRM. This result suggests that investors do not consider carbon risk management practices when they carry out their investment decisions. That is, firms that adopt strategies to improve their carbon and climate change risk practices are not rewarded by investors for their efforts. Therefore, this result does not support hypothesis 3a.

The lack of empirical support for hypothesis 3a contradicts some previous research, which concludes that better environmental performance and risk management lowers the cost of equity capital (Clarkson et al. 2010; Connors & Sliva-Gao 2009; Sharfman & Fernando 2008). Possible reasons for this conflict are as follows. First, investors may be still struggling with processing carbon information given the uncertainty that surrounds this phenomenon (Smith, Morreale & Mariani 2008). Second, differences between the context of prior research and this study, in which previous research has focused on various aspects of environmental issues whereas

this study focuses particularly on carbon emissions and climate change phenomenon. Third, the methodological differences in measuring the environmental performance and carbon risk management. While some studies have employed Toxic Release Inventory (TRI), scaled by sales (Clarkson et al. 2010; Connors & Sliva-Gao 2009) as performance proxy, other studies have used mixed of TRI data and KLD's environmental scores (Sharfman & Fernando 2008). As discussed in chapter one, this study employs a new performance measurement, which includes both of carbon emission levels as well as actions undertaken by firms to reduce carbon emissions and manage their response to climate change.

For the control variables, as expected and consistent with the literature (Botosan 1997; Fama & French 1992, 1993), BETA and BtoP are significantly and positively associated with the estimated cost of equity capital. This finding suggests that firms' cost of equity capital increases as the risk proxies (Beta and BtoP) increase. Therefore, this result confirms, to some extent, the validity of the ex-ante cost of equity capital proxy. However, in contrast to the literature, the firms' size is not significant with the ex-ante cost of equity capital. This insignificant result could be attributed to that all sample firms were drawn from G500, which are considered large firms. Once again, two additional regression analyses are performed based on total assets and market value as proxies for size. The results obtained are consistent with those when total sales is utilised. Finally, when industry membership is considered, the materials and information technology sectors show a positive and significant association with the cost of equity capital. This indicates that investors require a higher rate of return from these two sectors than they require from other sectors.

Previous results are based on the total scores of carbon risk management and disclosure for the pooled sample. To assess robustness of these results, several additional analyses are performed. These analyses are based on disaggregated carbon risk management and disclosure; intra-country and industry analyses and sensitivity analyses.

5.3.3 Regression results based on disaggregated carbon risk management and disclosure scores

The above regression tests are replicated by using carbon risk management and disclosure (CRM and CDIS2) components instead of total scores. These components include carbon risk management and disclosure about risks and opportunities associated with climate change; carbon emissions; carbon verification and trading; carbon performance; and carbon governance. This process is adopted to check whether stock market participants are interested in particular categories of carbon risk management and disclosure. Indeed, investors may be more interested in historical carbon risk management (historical information) than firms' commitment and future strategies adopted to reduce carbon emissions level and minimise climate change associated risks (forward looking information) .

To conduct this analysis, the ex-ante cost of equity capital is regressed on each carbon disclosure category with its matched category of carbon risk management (for more details about these categories see appendix 1). Results obtained (Untabulated) are consistent with those when total carbon risk management and disclosure scores are considered. None of carbon disclosure components are associated with the ex-ante cost of equity capital. These results suggest that investors

do not incorporate a particular category (neither historical nor future carbon risk management activities) in their decision- making process. The next section investigates whether previous results differ as a result of the differences between industries and countries.

5.3.4 Intra-industry and country analyses

Previous analyses are rerun within industry and country to avoid any industry and country specific effects on the pooled sample analysis. The intra-industry and country analyses yielded results that are generally consistent with the main results using pooled sample. These results suggest that carbon disclosure and carbon risk management have no impact on the ex-ante cost of equity capital. In addition, these results suggest that neither particular industry (e.g., high or low pollution industries), nor particular country (e.g., EU countries where carbon emissions trading scheme is in place) has an incremental explanatory power in explaining the association between carbon disclosure and risk management and the ex-ante cost of equity capital. In conclusion, the hypotheses 2a and 3a are not supported for any country group or industry sector.

5.3.5 Sensitivity tests

In this section, several sensitivity analyses are conducted to assess the robustness of the E (Ke) results. First, regression models 5 and 6 are rerun using an alternative specification for the estimation of the ex-ante cost of equity capital. This accomplished by using long-run earnings as suggested by Botosan and Plumlee (2005) in order to assure that the changes of abnormal earnings beyond the forecasts

horizon are zero. This is accomplished by using 3 and 4 years earnings forecasts rather than 5 years forecasts since that OSIRS database provides only 4 years ahead forecasts. This process results in reducing the sample to 200 observations. Nevertheless, the findings obtained are consistent with those when the earnings forecasts for one and two years are considered. The result confirms that there is no association between carbon disclosure and carbon risk management and the ex-ante cost of equity capital.

Second, hypotheses 2a and 3a are retested using a regression analysis taking into account one variable at a time, carbon disclosure or carbon risk management. These analyses are conducted following some literature that examined the impact of environmental performance on the cost of equity capital without controlling for environmental disclosure (Connors & Sliva-Gao 2009; El Ghoul et al. 2011; Sharfman & Fernando 2008), or vice versa (Dejean & Martinez 2009; Reverte 2011; Richardson & Welker 2001). Consistent with the results obtained in section 5.3.2, no association between the ex-ante cost of equity capital and either carbon disclosure or carbon risk management is observed.

Third, following Dhaliwal et al. (2011), an additional test is run in order to check whether the benefits of carbon disclosure are conditional on a firm's risk management. This test is conducted by using an interaction term between carbon disclosure and risk management as follows:

$$E(Ke)_{i,t} = \beta_0 + \beta_1 CDIS1_{i,t} + \beta_2 CRM_{i,t} + \beta_3 CDIS1_{i,t} * CRM_{i,t} + \beta_4 BETA_{i,t} + \beta_5 BtoP_{i,t} + \beta_6 SIZE_{i,t} + \beta_7 \sum IND_{i,t} + \varepsilon_{i,t} \quad (9)$$

$$E(Ke)_{i,t} = \beta_0 + \beta_1 CDIS2_{i,t} + \beta_2 CRM_{i,t} + \beta_3 CDIS2_{i,t} * CRM_{i,t} + \beta_4 BETA_{i,t} + \beta_5 BtoP_{i,t} + \beta_6 SIZE_{i,t} + \beta_7 \sum IND_{i,t} + \varepsilon_{i,t} \quad (10)$$

Once again, based on previous regression models, no association between carbon disclosure and risk management and the ex-ante cost of equity capital is observed. This analysis provides another indication that the investors do not appear to price any type of positive information about corporate carbon risk or its management.

5.3.6 Summary

Hypotheses 2a and 3a predict a negative relationship between carbon disclosure, carbon risk management and the ex-ante cost of equity capital. The regression results obtained from testing these hypotheses do not support the conjecture that investors require a lower rate of return from firms that improve their carbon disclosure and risk management practices. These results are robust to disaggregated carbon risk management and disclosure scores, intra-country and industry analyses as well as to several sensitivity analyses. Thus hypotheses 2a and 3a are rejected.

As mentioned in previous sections, this study investigates the interrelationships between carbon risk management, carbon disclosure and capital market indicators. The next section, discusses the results obtained from testing the association between carbon risk management and disclosure and firms' market value.

5.4 Empirical results for the relationship between carbon disclosure, carbon risk management and market value

This section presents the results obtained from testing the relationships between carbon disclosure (CDIS1 and CDIS2), carbon risk management (CRM) and market value (MV). These relationships are hypothesized in H2b and H3b (see chapter 2) as follows:

H2b - There is a positive relationship between the quality of carbon disclosure and firm market value.

H3b - There is a positive relationship between CRM and firm market value.

These hypotheses are tested by running regression models 7 and 8, which are developed in chapter 3.

5.4.1 Correlation results for hypotheses 2b and 3b

Table 5.10 displays the Pearson and Spearman correlations among market value (MV); carbon disclosure proxies (CDIS1, CDIS2); carbon risk management (CRM); and control variables. With regard to CDIS1, as can be seen from Panel A, Pearson and Spearman correlations show that CDIS1 and MV are positively and significantly associated. This result provides preliminary support for hypothesis 2b. This suggests firms with enhanced carbon disclosure quality have a higher market value than their counterparts with low carbon disclosure quality. That is, carbon disclosure via CDP has an influential impact on firm's market value. These results are consistent with those of non-parametric Spearman correlations.

For CDIS2, Panel B of Table 5.10 shows that MV is highly and positively correlated with CDIS2. Once again, this result provides preliminary evidence of a significant relationship between carbon disclosure and market value. In addition, previous results are consistent in both Pearson and Spearman correlations.

Table 5.10 Correlation matrix: (Pearson above diagonal, Spearman below)

$$MV_{i,t} = \Omega_0 + \Omega_1 CDIS1_{i,t} + \Omega_2 CRM_{i,t} + \Omega_3 BV_{i,t} + \Omega_4 ABE_{i,t} + \Omega_5 \sum IND_{i,t} + \varepsilon_{i,t}$$

$$MV_{i,t} = \Phi_0 + \Phi_1 CDIS2_{i,t} + \Phi_2 CRM_{i,t} + \Phi_3 BV_{i,t} + \Phi_4 ABE_{i,t} + \Phi_5 \sum IND_{i,t} + \varepsilon_{i,t}$$

Panel A: Correlation coefficients based on CDP disclosure					
	MV	**CDIS1**	**CRM**	**BV**	**ABE**
MV	1	0.141*	0.192**	0.657**	0.391**
CDIS1 (+)	0.146*	1	0.512**	0.121*	0.031
CRM (+)	0.183**	0.535**	1	0.206**	0.017
BV (+)	0.650**	0.129*	0.218**	1	0.415**
ABE (+)	0.427**	0.070	0.074	0.508**	1
Panel B: Correlation coefficients based on annual and sustainability reports and corporate websites disclosures					
	MV	**CDIS2**	**CRM**	**BV**	**ABE**
MV	1	0.167**	0.192**	0.657**	0.391**
CDIS2 (+)	0.189**	1	0.625**	0.229**	-0.024
CRM (+)	0.183**	0.631**	1	0.206**	0.017
BV (+)	0.650**	0.237**	0.218**	1	0.415**
ABE (+)	0.427**	0.039	0.074	0.508**	1

**,* represent significant levels at 0.01 and 0.05 (two-tailed) respectively.
Variables definition: **MV** is the market value of common equity in $ millions at the end of 2009; **CDIS1** is the carbon disclosure scores obtained from CDLI 2009; **CDIS2** is the carbon disclosure scores based on annual and sustainability reports and corporate websites; **CRM** is the carbon risk management scores; **BV** is the equity book value in $ millions at the end of 2009; **ABE** is the abnormal earnings (in $millions) defined as: earnings to common equity less an assumed cost of equity capital based on Easton's (2004) PEG ratio times the beginning of period book value of common equity; **IND** is a series of nine industry dummy variables: 1 = a company is from a particular industry group and 0 = otherwise. The telecommunications sector is excluded as reference sector.

With regard to hypothesis 3b, Panels A and B of Table 5.10 show that CRM is positively and significantly associated with market value. This result is consistent in both Pearson and Spearman correlations, and indicates that good carbon risk management practices are positively associated with firms' market value. Finally, for the control variables, consistent with the assumption of Ohlson's (1995) model and literature, firms' book value (BV) and abnormal earnings (ABE) are positively and significantly associated with market value. The next section discuses the results obtained from regressing market value on carbon risk management and disclosure.

5.4.2 Regression results for hypotheses 2b and 3b

Table 5.11 presents the regression results of the association between carbon disclosure and risk management and a proxy for firm's market value. Hypotheses 2b and 3b predict that carbon disclosure (CDIS1 and CDIS2) and carbon risk management (CRM) are positively associated with market value (MV).

In regard to CDIS1, model 7 has an adjusted R^2 of 0.655 with *F* statistic of 38.524 with a *P*-value of 0.000. This implies that the explanatory power of the model is high, and 65.5 per cent of data are processed in this model. While the correlation matrix presented earlier showed a statistically significant positive relationship between CDIS1 and MV, this relationship is weak when other relevant factors are controlled. That is, carbon disclosure via CDP is not statistically significantly associated with firms' market value over and above the book value and abnormal earnings. Therefore hypothesis 2b is rejected.

Table 5.11 Regression results for the relationship between market value, carbon disclosure and carbon risk management (full sample)

$$MV_{i,t} = \Omega_0 + \Omega_1 CDIS1_{i,t} + \Omega_2 CRM_{i,t} + \Omega_3 BV_{i,t} + \Omega_4 ABE_{i,t} + \Omega_5 \sum IND_{i,t} + \varepsilon_{i,t}$$

$$MV_{i,t} = \Phi_0 + \Phi_1 CDIS2_{i,t} + \Phi_2 CRM_{i,t} + \Phi_3 BV_{i,t} + \Phi_4 ABE_{i,t} + \Phi_5 \sum IND_{i,t} + \varepsilon_{i,t}$$

variable	**Regression results based on CDP disclosure (CDIS1)**			**Regression results based on sustainability reports disclosures (**CDIS2**)**		
	Coefficient	**t-value**	***P*- value**	**Coefficient**	**t-value**	***P*- value**
Intercept	2.810	11.798	0.000	2.871	11.934	0.000
CDIS1	0.001	1.371	0.172			
CDIS2				0.001	0.526	0.600
CRM	0.000	0.449	0.654	0.001	0.801	0.424
BV	0.592	16.659	0.000**	0.589	16.181	0.000**
ABE	0.054	3.077	0.002*	0.055	3.073	0.002*
Industrials	-0.062	-0.963	0.337	-0.059	-0.911	0.363
Consumer Discretionary	-0.014	-0.211	0.833	-0.007	-0.098	0.922
Consumer Staples	0.122	2.037	0.043*	0.127	2.120	0.035*
Energy	-0.043	-0.705	0.481	-0.038	-0.626	0.532
Financials	-0.200	-3.534	0.000**	-0.187	-3.335	0.001*
Materials	-0.069	-1.070	0.286	-0.065	-0.995	0.321
Utilities	-0.212	-3.528	0.001*	-0.206	-3.407	0.001*
Health Care	0.091	1.421	0.157	0.107	1.706	0.089
Information Technology	0.141	2.237	0.026*	0.148	2.351	0.020*
Adj.R^2	0.655			0.653		
F-statistic	38.524**			38.150**		

Dependent variable is market value in millions at the end of 2009. **,* represent significant levels at 0.001 and 0.05 respectively.

Variables definition: **MV** is the market value of common equity in $ millions at the end of 2009; **CDIS1** is the carbon disclosure scores obtained from CDLI 2009; **CDIS2** is the carbon disclosure scores based on annual and sustainability reports and corporate websites; **CRM** is the carbon risk management scores; **BV** is the equity book value in $ millions at the end of 2009; **ABE** is the abnormal earnings (in $millions) defined as: earnings to common equity less an assumed cost of equity capital based on Easton's (2004) PEG ratio times the beginning of period book value of common equity; **IND** is a series of nine industry dummy variables: 1 = a company is from a particular industry group and 0 = otherwise. The telecommunications sector is excluded as reference sector. VIF values are all lower than 3.0 except for the Financials industry with values of 3.022 in CDIS1 model.

This result indicates that better carbon disclosure quality that made by responding to CDP's questionnaire is not reflected in enhancing firms' market value. That is, stock market participants do not effectively assess carbon information that is released via CDP. Recall that market value is a function of the cost of equity capital and cash flows (Lambert, Leuz & Verrecchia 2007; Plumlee et al. 2010; Plumlee, Brown & Marshall 2008; Richardson, Welker & Hutchinson 1999), this result seems reasonable since no evidence was found for a relationship between carbon disclosure and ex-ante cost of equity capital.

For the CDIS2, model 8 has an adjusted R^2 of 0.653 with F statistic of 38.150 and a *P*-value of 0.000. Once again, in spite of the correlation matrix showing a significant positive correlation between CDIS2 and MV, these correlations are not statistically strong enough to infer significant regression results. CDIS2 is found to have positive but not significant relationship with MV. This result confirms the results obtained based on CDIS1.

A possible interpretation for the absence of an association between carbon disclosure and market value is that investors may rely more on other information channels such as toxic release data to assess carbon emissions and risk management. This explanation accords with Clarkson et al.'s (2010) finding that environmental disclosure does not provide any incremental value beyond toxic release data. Therefore, from the investors' perspective, carbon disclosure per se may not necessarily warrant economic benefits (Dhaliwal et al. 2011). Thus, these results reject hypothesis 2b which predicts a positive association between carbon disclosure and a firm's market value.

The results for CDIS1 and CDIS2 are consistent with some of the previous research. Dragomir (2010) for example, finds that European firms that disclose more about their environmental activities do not necessarily reap financial benefits from such disclosure. In addition, Gans and Hintermann (2011) find that the announcement of voluntarily participating in the Chicago Climate Exchange (CCX) has no impact on excess returns. On the other hand, these results contradict other relevant studies. Chapple, Clarkson and Gold (2011) and Matsumura, Prakash and Vera-Muñoz (2011) and Fisher-Vanden and Thorburn (2011) find that disclosure about carbon emissions or engagement with climate change initiatives is negatively associated with firms' stock price. This conflict could be attributed to the methodological differences between the current study and previous research.

For hypothesis 3b, regression results from Table 5.11 show that CRM is not associated with MV. Despite the significant positive correlation based on Pearson and Spearman's coefficients, this relation is not strong enough to draw the conclusion that carbon risk management and market value are significantly and positively associated. Hence, these results suggest that firms taking actions to reduce their carbon emissions and minimise the climate change's negative impact are not rewarded by stock market participants. This behaviour is open to several interpretations. First, investors do respond to firms' carbon risk management activities, but this response is not strong enough to enhance these firms' market value. Second, market participants may not know how to interpret carbon risk management related information; thus they do not consider this information to be useful or they do not know how to value it.

The result concerning carbon risk management corroborates some prior research. Moneva and Ortas (2008) and Curran and Moran (2007) for instance, find that inclusion in a socially responsible index is not necessarily reflected in increasing stock returns. Moreover, firms that engage with carbon reduction schemes or employ carbon reduction technologies are not rewarded by stock market participants (Beatty & Shimshack 2010; Fisher-Vanden & Thorburn 2011; Gans & Hintermann 2011; Lee, Faff & Langfield-Smith 2009).

For control variables, book value and abnormal earnings show a positive and significant association with market value (*P*-values are 0.000 for book value and 0.002 for abnormal earnings for the two disclosure specifications). These results are consistent with Ohlson's (1995) assumption and the literature, indicating that firms' market value increases with the increase of their book value and abnormal earnings.

Previous analyses are conducted based on aggregated carbon risk management and disclosure scores as well as a pooled sample. Hence, additional analyses are run to validate previous results. The next section discusses the results of regressing market value on disaggregating carbon risk management and disclosure scores.

5.4.3 Regression results based on disaggregated carbon risk management and disclosure scores

Similar to analyses conducted in section 5.3.3, the above regression tests are replicated by using carbon risk management and disclosure components instead of total scores (CRM and CDIS2). To conduct these analyses, market value is regressed on each carbon disclosure category with its matched carbon risk management's

category (for more details about these categories see appendix 1). Untabulated results show that none of these categories is associated with market value. That is, the disclosure about historical and future carbon risk management activities seems not to affect stock market participants, and consequently does not affect a firm's market value. These are surprising results since the disclosure about these categories and activities was requested by CDP, which represents an investors' coalition.

The results discussed in previous two sections still inconclusive since they obtained based on pooled data. The next section presents the results from testing the association between carbon risk management and disclosure and market value within the sample industries and countries.

5.4.4 Intra-industry and country regression analyses

Regression analyses in section 5.4.2 are rerun by industry sectors and country groups to explore whether these results differ from those using the full sample. Ten industry sectors with sub-sample sizes ranging between 19 for telecommunications and 56 for financials are examined. In addition, the country groups examined are North America, UK, EU, and Asia Pacific and sub-sample sizes range between 27 for the UK and 132 for North America. No relation between carbon disclosure and carbon risk management and market value is observed for any of the individual country or industry sector sub-samples.

5.4.5 Sensitivity test

Two additional tests are performed to assess the robustness of results discussed in section 5.3.2. First, hypotheses 2b and 3b are retested using a regression analyses for CDIS1, CDIS2 and CRM separately. These analyses are performed to check the value relevance of individual carbon disclosure and carbon risk management. Untabulated analyses indicate that the variables of interest (CDIS1, CDIS2 and CRM) are not significantly associated with market value. However, carbon disclosure via CDP has a marginal positive association with a *P*-value of 0.062. A plausible explanation for this result is that the investors' coalition (CDP) asked firms to provide carbon information. Thus, investors have priced this information.

A second test is undertaken by employing the Collins, Maydew and Weiss (1997) valuation model, which replaces the abnormal earnings in the Ohlson's valuation model with regular earnings (net income minus extraordinary items). This process is adopted since calculating abnormal earnings requires estimating the cost of equity capital. Thus, employing earnings instead of abnormal earnings avoids some weaknesses that are inherent in the cost of equity capital proxy. Untabulated results are similar to those obtained in section 5.3.2, that better carbon disclosure and risk management practices are not associated with increase in a firm's market value.

5.4.6 Summary

Section 5.4 discusses the main results from testing hypotheses 2b and 3b. These hypotheses predict a positive association between carbon disclosure, carbon risk management and market value. Regression results show no strong association between carbon risk management and disclosure and market value. Thus, the

conjecture of positive economic consequences of adopting good carbon risk management strategies and the disclosure about these activities is rejected. That is, a firm's decision to engage in carbon risk management and disclosure practices are not rewarded by stock market participants. These results are robust to disaggregated carbon risk management and disclosure scores, intra-country and industry analyses as well as to several sensitivity analyses. Thus hypotheses 2b and 3b are rejected.

5.5 The relationship between CDIS and CRM and non-investor stakeholder perceptions

Previous sections have revealed the weak reaction of investors to disclosures about carbon risk management practices. Hence, these results raise the question whether management's adoption of carbon and climate change risk activities as well as releasing information about these activities are mainly directed to the capital market participants or to manage non-investor's perceptions. That is, do firm's management use these activities to deal with other stakeholders rather than only investors?

This question is answered by employing Clarkson et al.'s (2010) regression model and test whether carbon disclosure is associated with the public's perceived carbon risk management as measured by Janis-Fadner coefficient of stakeholder sentiment as follows:

$$\text{J-Fcoe}_{i,t} = \alpha_0 + \gamma_1 \text{CDIS1}_{i,t} + \gamma_2 \text{CRM}_{i,t} + \gamma_3 \text{SIZE}_{i,t} + \sum \text{IND}_{i,t} + \varepsilon \quad (11)$$

$$\text{J-Fcoe}_{i,t} = \alpha_0 + \gamma_1 \text{CDIS2}_{i,t} + \gamma_2 \text{CRM}_{i,t} + \gamma_3 \text{SIZE}_{i,t} + \sum \text{IND}_{i,t} + \varepsilon \quad (12)$$

Where J-Fcoe is the carbon legitimacy proxy which captures the social pressure and non-investor stakeholder perceptions about a firm's carbon risk management (for more details about the measurement of J-Fcoe see chapter 3).

Table 5.12 presents the results obtained from regressing carbon legitimacy proxy (J-Fcoe) on carbon disclosure and risk management. Panels A and B both show a significant positive association between the carbon legitimacy proxy and firms' carbon risk management score (CRM) rather than the carbon disclosure score (CDIS1, CDIS2). These results suggest that firms do not use their carbon disclosures to manage non-investor stakeholders' impression about their carbon and climate change activities. Instead, these firms employ their carbon risk management activities to manage non-investor stakeholders' perceptions. These results seem intuitive since the carbon legitimacy proxy originates from other information channels. These channels are the public media channels (newspapers and magazines). That is, firms use the media to advise stakeholders of good carbon risk management activities rather than utilising sustainability report disclosures. This result is contrary to Clarkson et al. (2010) who find that firms use environmental disclosure to manage the public perception about their environmental performance.

For robustness, additional analyses are performed. The first set of analyses is conducted by regressing carbon legitimacy proxy on carbon risk management and disclosure proxies separately. When CRM is not included in the models, the two disclosure measures (CDIS1 and CDIS2) are significantly positively related to carbon legitimacy proxy (P-value = 0.06 and 0.017), whereas when CRM included separately, it still positive and significant (P-value = 0.000).

Table 5.12 Regression results of J-F coefficient on CDIS and CRM

Panel A: regression results based on CDP				
		CDIS1	**CRM**	**SIZE**
Coefficient		0.003	0.005	0.108
t-Statistics		1.146	2.541	1.416
P- value		0.253	0.012*	0.158
Intercept	-0.883			
Adj.R^2	0.080			
F-statistic	3.073**			
Panel B: regression results based on annual and sustainability reports and corporate websites				
		CDIS2	**CRM**	**SIZE**
Coefficient		0.002	0.006	0.102
t-Statistics		0.517	2.670	1.318
P- value		0.606	0.008*	0.189
Intercept	-0.731			
Adj.R^2	0.076			
F-statistic	2.974**			

**,* represent significant levels at 0.001 and 0.05 respectively.

Variables definition: **J-Fcoe** is the Janis-Fadner coefficient; **CDIS1** is the carbon disclosure scores obtained from CDLI 2009; **CDIS2** is the carbon disclosure scores based on annual and sustainability reports and corporate websites **CRM** is the carbon risk management scores; **SIZE** is the natural logarithm of total sales; **IND** is a series of nine industry dummy variables: 1 = a company is from a particular industry group and 0 = otherwise. The telecommunications sector is excluded as reference sector.

Overall, these results seem to suggest that disclosures do not provide any additional information to non-investor stakeholders over and above CRM performance, and those stakeholders can access other information channels such as media channels or government agencies (such as EPA) to obtain carbon risk management relevant information. However if non-investor stakeholders are unable to determine CRM, then carbon disclosures may be useful.

The second set of analyses is carried out by regressing carbon legitimacy proxy on disaggregated carbon risk management and disclosure scores. These analyses are

undertaken to check whether managers use particular categories of their carbon risk management and disclosure to manage non-investors' perceptions. Regression results (Untabulated) show that none of carbon disclosure categories are associated with carbon legitimacy proxy. In contrast, all carbon risk management categories, except for the emissions accounting category, are positively and significantly associated with carbon legitimacy proxy (J-Fcoe). These categories are actions to manage, adapt to or minimise the risks and maximise the opportunities identified, verification and carbon trading activities, goals and plans to undertake to reduce carbon emissions and energy use, and activities relevant to corporate governance to practices to account for climate change risk.

There are two possible explanations for these results. First, non-investor stakeholders are more interested in prospective risk management activities rather than in historical risk management (such as historical carbon emissions levels). Second is that those stakeholders are able to access other information channels such as TRI. These results are consistent with those obtained in section 5.2.4, that all carbon disclosure categories are associated with their matched carbon risk management categories except for the carbon emissions category. Indeed, managers use their strategic and future carbon risk management activities rather than their historical carbon emission levels to manage non-investor stakeholders' perceptions.

5.6 Chapter summary

This chapter provides the empirical results from hypotheses tests undertaken in this research. Section 5.2 discusses the main results from testing hypothesis 1, which predicts the existence of a relationship between carbon risk management and carbon

disclosure. These results support the argument of economic-based disclosure theories (signalling and voluntary disclosure theories), which predict that carbon disclosure quality is positively associated with carbon risk management practices.

Section 5.3 provides the results of hypotheses 2a and 3a, which conjecture that carbon disclosure and carbon risk management are negatively associated with the ex-ante cost of equity capital. Based on regression results, neither negative nor positive association is observed. Thus, these results do not support the assumption of Lambert, Leuz and Verrecchia (2007) and Richardson, Welker and Hutchinson (1999) about the capital market reaction to improving carbon disclosure level. In addition, these results do not support the assumptions of cost and risk approaches, which predict that better carbon risk management practices should be reflected in lowering the ex-ante cost of equity capital.

Section 5.4 provides the empirical results from examining hypotheses 3a and 3b. These hypotheses assume that firms' market value is positively correlated with the quality of carbon risk management and carbon disclosure practices. Based on regression tests, carbon risk management and disclosure are not significantly associated with market value. These results suggest that market participants do not integrate the disclosure about carbon risk management in investment practices. This is an interesting result since many endeavours have been initiated by investors to enhance firms' carbon disclosure and performance (Sorensen & Pfeifer 2011). Therefore, once again, the argument of Lambert, Leuz and Verrecchia (2007) and Richardson, Welker and Hutchinson (1999) about the economic benefits of improving carbon disclosure level are not supported. Additionally, the assumptions

of cost and risk approaches about the positive economic consequences of adopting some carbon and climate change strategies are rejected.

Finally, given the insignificant associations between carbon risk management-disclosure and stock market indicators, further analysis is conducted in section 5.5 to investigate whether carbon practices are used by managers to influence non-investor's perceptions. Regression results indicate that carbon disclosures do not appear to play a role in managing other stakeholders' perceptions about a firm's carbon risk management performance once this performance is controlled. However, a significant and positive relationship between carbon legitimacy and carbon risk management is observed, while carbon disclosures have no additional explanatory power. Thus, it could be concluded that firms' management use their carbon risk management practices to influence non-investor stakeholders' perceptions about their performance rather than disclosure per se.

Previous results are robust to several additional analyses. These analyses are run based on disaggregated carbon risk management and disclosure scores, within sectors and countries. Relevant to hypothesis 1, regression analyses show that the positive relationship between carbon risk management and disclosure varies based on the disclosure type. A positive association between firms' actions and commitments to deal and mitigate climate change risks and the quality of disclosure about these actions is observed. Nevertheless, this association is not detected between the emission intensity and the disclosure about actual emissions and methodology and details of calculating these emissions. This implies that firms' management tend to disclose high quality information about their current and future

carbon risk management strategies rather than focusing on the disclosure about actual and historical carbon emissions levels. In terms of intra- industry and country analyses, the significant and positive association between carbon risk management and disclosure is observed within all sectors and countries except for the materials sector and the UK context. For hypotheses 2 (a) and (b), 3 (a) and (b), the additional analyses support major results that better carbon risk management and disclosure practices are not associated with a reduction in the ex-ante cost of equity capital and an increase in market value.

The next chapter provides the conclusions drawn from these results about the research questions, and discusses the implications of this research for theory, policy and practice.

CHAPTER 6 CONCLUSIONS AND IMPLICATIONS

6.1 Introduction

This chapter concludes the thesis and summarises the major findings from chapter 5. Section 6.2 draw conclusions about the research questions developed in chapter 1. Section 6.3 identifies several implications for theory and practice. Section 6.4 discusses the limitations of this study, while section 6.5 outlines a number of areas for future research.

6.2 Conclusions about research questions

This research undertakes a comprehensive examination of the direction and extent of relationships between carbon risk management, carbon disclosure and stock market indicators. The following questions are investigated:

1- What is the direction and extent of the association between carbon risk management and carbon disclosure?

2- What is the direction and extent of the association between carbon disclosure and the ex-ante cost of equity capital and market value?

3- What is the direction and extent of the association between carbon risk management and the ex-ante cost of equity capital and market value?

The next three sub-sections (6.1.1, 6.1.2 and 6.1.3) discuss the conclusions about these questions based on the analyses conducted in chapter 5.

6.2.1 What is the extent of the association between carbon risk management and carbon disclosure?

Much past research has supported socio-political aspects as key determinants of environmental disclosure, without paying much attention to important firm characteristics, such as environmental performance. On one hand, in the context of socio-political theories (legitimacy and stakeholder theories), firms' tendency to disclose carbon information is a function of their exposure to social and political pressure. That is, firms disclose this information to maintain their legitimacy and in response to powerful stakeholders. Hence, legitimacy and stakeholder theories posit a negative relationship between environmental performance and disclosure. On the other hand, economic-based disclosure theories (signalling and voluntary disclosure theories) argue that firms signal their environmental and carbon risk management quality to differentiate themselves from poor quality firms. In addition, they do so to mitigate information asymmetry problems and to reap some economic benefits. Therefore, these theories assume a positive relationship between environmental performance and disclosure.

The regression results obtained from testing the hypothesis for this research question show a significant positive association between carbon risk management and carbon disclosure. This association is observed for disclosures made via CDP as well as other corporate reporting channels. Therefore, these results lend support to the economics-based disclosure theories. Firms that respond to and deal well with carbon and climate change risks and opportunities disclose more information about their strategies and policies. Indeed, these firms convey this information to signal their performance quality related to climate change. In addition, superior firms in

terms of their carbon risk management practices release this information to differentiate themselves from inferior firms. This disclosure helps firms in reducing information asymmetry problems between the firm and external parties, especially its investors. For example, these firms are doing so in an attempt to inform investors about their carbon emissions, their exposure to climate change's risks, and how they deal with these issues. If these firms did not release this information, they could expect to be penalised by investors. In particular, investors may require a higher rate of return on their investment since they would need to incur additional costs to obtain this information.

The significant positive association between carbon risk management and disclosure quality is supported when this research question is retested based on several specific carbon risk management and disclosure categories (disaggregated scores). This is evident since the CDLI 2009 methodology captures the quality rather than merely the quantity or the level of disclosure (for more details see chapter 3 and appendix 1). All carbon disclosure categories are positively correlated with carbon risk management, except for the carbon intensity category. This indicates that firms disclose high quality and credible information about their future and strategic carbon and climate change actions to reduce carbon emissions levels and mitigate climate change associated risks. These aspects include climate change associated risks and opportunities, carbon verification and trading, carbon performance and governance. On other hand, carbon intensity and the disclosers about actual carbon emissions and carbon accounting methods to calculate these emissions are not associated. This suggests that a firm's management does not consider historical carbon emissions as a part of its risk management activities. Hence, this result provides evidence on prior

research that proxied environmental performance by total toxic emission or the recycled emissions. Additionally, these results highlight the benefits of partitioning carbon risk management and disclosure scores into their components instead of relying on aggregated indices.

Furthermore, intra-industry and country results support the significant and positive relationship between carbon risk management and disclosure with few exceptions. This significant and positive association was not supported based on the two disclosure proxies for the materials sector and the UK, whereas this association is observed with one of the two disclosure proxies within some industries. However, other factors are found to be carbon disclosure's drivers in the material sector and UK cases. In respect of the materials sector, profitability appears as the main driver of carbon disclosure. In the UK, the stakeholders' calls to disclose carbon information and the carbon reduction schemes might be drivers for carbon disclosure. Finally, while this significant and positive association is detected in four sectors through the two carbon disclosure proxies, the remaining sectors show different results. Carbon risk management is positively associated with only carbon disclosure via CDP within the consumer staples and financials sectors. In contrast, carbon risk management is positively associated with only carbon disclosure via sustainability reports within the consumer discretionary, health care, and energy sectors. Overall, appart from these specific industry and country differences, sample firms disclose their carbon information as a reflection of their good carbon risk management practices.

Finally, the socio-political theories' prediction that carbon disclosure is a function of social and political pressure and carbon legitimacy threats is rejected when carbon risk management is considered. Results of additional tests show that when carbon risk management is excluded from the analysis, the carbon legitimacy proxy appears as the main driver of carbon disclosure. However, when carbon risk management is included, the association between the carbon legitimacy proxy and carbon disclosure disappears. Thus, these results raise the importance of considering the underlying environmental performance when investigating corporate environmental disclosure determinants. In conclusion, this study's results provide evidence that carbon risk management is a key determinant of carbon disclosure practices. That is, the more firms enhance their carbon risk management practices, the more and better quality carbon information they report.

6.2.2 What is the extent of the association between carbon disclosure and the ex-ante cost of equity capital and market value?

This research question examines the potential association between carbon disclosure and stock market indicators. That is, to what extent does enhancing carbon disclosure practices manifest in the ex-ante cost of equity capital and market value. According to Lambert, Leuz and Verrecchia (2007), carbon disclosure could reduce the ex-ante cost of equity capital directly. This can be achieved through a reduction in estimation risk and/or increased market liquidity for the firm's securities.

In addition, Based on Lambert, Leuz and Verrecchia's (2007) and Richardson, Welker and Hutchinson's (1999) models, the reduction in cost of equity capital

improves future cash flows of disclosing firms. These activities are predicted to enhance disclosing firms' market value.

Based on regression results, no association between carbon disclosure and the ex-ante cost of equity capital is observed. This result indicates that while investor interest in climate change information is increasing, use of this data is not yet widespread amongst mainstream investors. This behaviour could be interpreted in several ways. First, investors may not consider carbon and climate change risks to be material. Haigh and Shapiro (2010) (cited in DEFRA (2010)) conclude that one of the most significant reasons for the muted level of interest in climate related risk and carbon emissions data is the perceived poor suitability of unpriced carbon data for investment purposes. Second, market participants may not be confident about the (often not assured) information released and consider it to lack credibility (Cormier & Magnan 2003).

In regard to the relationship between carbon disclosure quality and firm value, regression results do not indicate the existence of such a relationship. That is, neither a positive nor negative association is observed. This result seem plausible since one of the market value components, which is the cost of equity capital (Plumlee et al. 2010; Plumlee, Brown & Marshall 2008) does not decrease as a result of enhancing carbon disclosure practices. This may result in reduced market participant expectations about future cash flows.

6.2.3 What is the extent of the association between carbon risk management and the ex-ante cost of equity capital and market value?

This research question aims to investigate the association between carbon risk management practices and the ex-ante cost of equity capital and market value. First, this study predicts that the ex-ante cost of equity capital is lower for firms with better carbon risk management practices. This is because investors could be expected to accept a lower rate of return on investments in firms that espouse new strategies and orient themselves toward reducing their carbon emissions and tackling climate change risks. That is, these firms have lower climate change risks than their competitors.

Second, the cost and risk approaches are fused to help examine the value relevance of carbon risk management, That is, while the cost approach assumes that market value is associated with the investors' perspectives about the environmental costs, the risk approach contends that a firm's value is determined by its exposure to environmental risks. Thereby, a firm's value is in part a function of environmental costs and risks. In the context of climate change, costs of investing in renewable energy or clean technologies to reduce carbon emissions are expected to produce future savings, and improve a firm's competitive position in new carbon markets (Hassel, Nilsson & Nyquist 2005; Lash & Wellington 2007). In addition, action to reduce carbon emissions' level, and exposure to climate change's risks are value relevant. Indeed, these actions change the investors' perception toward a firm and reduce the risk inherent from climate change, and consequently enhance the firm's market value.

In respect of the association between carbon risk management and the ex-ante cost of equity capital, the empirical findings of this research provide no evidence for the existence of this relationship. The results indicate that investors do not incorporate carbon and climate change associated risk when they make investment decisions. This behaviour could be interpreted in several ways. First, investors do not link good carbon risk management practices to lower risk. Consequently, the expected future of earnings of carbon risk management leaders is equal to those of laggards. Hence, investors perceive these practices neutrally, and do not orient their investment decision on this basis. Another possible reason for this behaviour is the uncertainty associated with carbon and climate change risks and opportunities (Matsumura, Prakash & Vera-Muñoz 2011; Sorensen & Pfeifer 2011). Therefore, investors are not confident about the future of firms' financial performance as a result of their exposure to these risks. For these reasons, better carbon and risk management activities are not reflected in a reduction in the ex-ante cost of equity capital.

With regard to the association between carbon risk management and market value, multivariate analyses do not show a statistically significant relationship between these two constructs. As a result, the current study concludes no association between carbon risk management and market value. This result suggests that firms' actions to reduce their carbon emissions and tackle climate change impacts are not valued by stock market participants.

There are four possible explanations for this behaviour. First, investors may not know how to interpret carbon risk management related information; thus, they do not consider this information to be useful or they do not know how to value it. Second,

investors may not be confident about the future of carbon and climate change related regulations and which firms will be targeted by these regulations. Therefore, because of their potential exposures to regulatory and physical climate change risks, these firms may be considered as risky firms. Thus, investors are not able to decide whether to invest in firms that could be affected by such regulations. Third, the absence of reliable data and information about carbon risk management activities makes it difficult for investors to rely on such information for their investment decisions. Finally, investors are not interested in carbon risk management and disclosure activities or do not believe that engaging with such activities could lead to change in a firm's reputation and competitive advantage. Hence, they do not trade these firms' shares on this basis.

Given the non-significant association between carbon risk management and disclosure and stock market indicators, an additional analysis is performed to check whether a firm's management uses carbon disclosure to manage non-investor stakeholders' perceptions about their carbon risk management activities. The next section discusses the conclusions about this analysis.

6.2.4 The relationship between carbon disclosure and risk management and non-investor stakeholder perceptions

This additional analysis is performed to check whether a firm's managers use carbon disclosure and risk management practices to manage non-investor stakeholders as measured by carbon legitimacy proxy (J-Fcoe). Given that non-significant associations between carbon disclosure and risk management and both of ex-ante cost of equity capital and market value, there is possibility that these practices are

adopted to deal with other stakeholders' perceptions. Regression results show that while carbon disclosure is not associated with non-investor stakeholders' perceptions; carbon risk management is positively and significantly associated. These results seem to suggest that disclosures do not provide any additional information to non-investor stakeholders over and above carbon risk management. Thus, it could be concluded that firms' management use their carbon risk management activities to influence non-investor stakeholders' perceptions about these activities rather than disclosure per se. This can be accomplished since stakeholders can access other information channels such as media channels or government agencies.

6.3 Implications of the study

This study is among few recent, mostly unpublished studies which empirically test one or more aspects of the relationship between carbon risk management and disclosure and their consequential impacts on stock market indicators. It differs from and extends this body of research in several important ways, and thus makes a valuable contribution to the literature and has implications for policy and practice in this area.

6.3.1 Implications for literature

This study extends the environmental performance and disclosure literature by applying it to carbon risk management and carbon disclosure. The conclusions from this research have several theoretical implications. First, this study extends prior research on carbon and climate change by considering a broad range of aspects

relevant to carbon performance rather than relying merely on carbon emission levels. That is, while most prior research has employed carbon emissions as a proxy for carbon performance, this study has incorporated and added several other aspects expected to be of interest to firms' stakeholders. These aspects include: actions taken by firms to minimise climate change risks and maximise opportunities, activities taken and plans to reduce carbon emissions and energy use, emerging new corporate governance practices, and the methods and assumptions used to account for carbon and climate change issues. Thus, this comprehensive investigation extends the study of climate change well beyond emissions levels.

Second, while most previous studies were conducted in the USA and less of them in Europe, the current study appears to be the first known to use a global sample (G500 firms). Hence, this sample enhances the external validity of this study, which, in turn, makes its conclusions more valid for generalisation purposes. Additionally, the use of a global sample allows intra-country comparisons to explore differences between countries.

Third, the results of this study provide useful insights about carbon risk management and disclosure practices through a comprehensive theoretically driven approach. Most of previous research has investigated environmental and carbon performance and disclosure practices by focusing separately on different determinants of these practices. The current research covers this gap by incorporating a range of internal firm specific characteristics and external factors such as social and political issues in exploring carbon disclosure determinants. The current study's results indicate that a firm's carbon risk management is the key driver of its carbon disclosure quality.

Fourth, firms' management uses different avenues of disclosure to release different information to different audiences and for different purposes (De Villiers & van Staden 2011; Simnett, Vanstraelen & Chua 2009). In relation to carbon disclosure, Tran, Okafor and Herremans (2010) find substantial differences in emissions figures disseminated via different reporting channels. Accordingly, this study provides an examination of multiple corporate reporting channels (annual and sustainability reports, corporate websites, and via CDP) rather than relying on just one or two disclosure channels. Therefore, the disclosure proxies used in this research address the shortcomings of some previous research that omits information released via other communication channels.

Fifth, this study supports the argument of economics-based disclosure theories (signalling and voluntary disclosure theories) which predict a positive association between environmental performance and disclosure. The current study finds that superior carbon risk management practices enhance carbon disclosure practices. At the same time, this conclusion raises two questions about the findings of prior research. First, the validity of some prior research's findings is questionable since it has not controlled for the underlying performance when studying disclosure behaviour. Second, results obtained in section 5.2.4 indicate that all carbon disclosure categories are positively and significantly associated with carbon risk management categories except for the carbon emission category which is associated with a carbon legitimacy proxy. These results bring into question the results of some studies that support legitimacy theory based on analyses conducted on just emissions' information.

Finally, many prior studies and reports have revealed the importance linking climate change phenomenon to stock market impacts (Labatt & White 2007; Lash & Wellington 2007; Sorensen & Pfeifer 2011; Stern 2008). In addition, large investor coalitions and organisations have called for firms to take actions that reduce their exposure to climate change related risks and to provide transparent disclosure about the actions that they take to achieve this (CERES 2003; Jeswani, Wehrmeyer & Mulugetta 2008; Sorensen & Pfeifer 2011). However, the current study finds that better carbon risk management and disclosure are not associated with a reduction of ex-ante cost of equity capital or increased market value. This suggests that carbon risk management and disclosure practices are still in their infancy in terms of playing decisive roles in investment decisions processes. These results do not support the premises of Lambert, Leuz & Verrecchia's (2007) model and cost and valuation theory about the linkage between environmental performance-disclosure and stock market benefits.

6.3.2 Implications for policy and practices

In addition to the above mentioned contributions to the literature, the findings of this study have important implications for policy makers and practitioners. First, institutional investors and affiliated organisations such as the Carbon Disclosure Project (CDP) can use this study's results (especially those based on disaggregated carbon risk management and disclosure scores) to better understand to what extent firms are considering and disclosing their carbon risk management activities and how capital markets react to these activities. Further, some other society members such as environmental activists could use this study to coerce firms, through institutional investor coalitions, to exert more pressure on firms to take effective

actions to tackle climate change risks. In addition, they may decide to call for more detailed and transparent disclosure about these actions.

Second, corporate regulators may find this study's results useful in understanding the role of carbon information in the stock market, which will help them in setting future regulations. The conclusion of no significant relationship between carbon disclosure and market value could be attributed to the lack of unified disclosure standards. Another possible explanation for this result is the reliability of carbon disclosures. Standardised reporting requirements from regulators would reduce this problem. This claim is consistent with the Smith, Morreale and Mariani's (2008) argument that the hesitation or reluctance of some firms to respond to the CDP questionnaire or GRI guidelines may necessitate the need to move to mandatory climate change reporting.

Finally, a firm's management could use the results of this research to better understand the potential advantages and disadvantages of undertaking and disclosing carbon reduction activities. The weak response by investors toward carbon risk management and disclosure practices could stimulate firms' management to enhance their performance in this regard and inform their shareholders about these activities effectively. This could result in gaining some economic benefits as suggested by theory such as reducing the cost of equity capital and increase their firms' market value.

6.4 Limitations of the study

Although this study is one of the more holistic studies that investigate corporate environmental performance and disclosure and their impact on capital market performance, it still has some limitations. First, as a result of the unavailability of data, this thesis resorted to employing one proxy to estimate the ex-ante cost of equity capital. This proxy is based on the PEG ratio (r_{PEG}) method developed by Easton (2004). This is inconsistent with many prior studies which have utilised several alternative methods separately (Clarkson et al. 2010; Connors & Sliva-Gao 2009), or by taking the mean of different proxies (Dhaliwal et al. 2011; El Ghoul et al. 2011; Orens, Aerts & Cormier 2010; Plumlee, Brown & Marshall 2008). However, r_{PEG} method is considered to dominate other proxies that estimate the ex-ante cost of equity capital (Botosan & Plumlee 2005; Botosan, Plumlee & Wen 2011). In addition, the current results relevant to risk proxies (beta and book to market ratio) that are known to be associated with cost of equity capital lend some support for this proxy.

Second, the time period of this study is restricted to one year, which may affect the explanation of disclosure behaviour. That is, carbon disclosure may need a longer time to be processed and analysed by investors, and then to be reflected in the cost of equity capital and market value. Thus, a one-year study may fail in capturing a relationship that might take a longer period to occur. Also, carbon risk management and disclosure practices are expected to increase over time and investors' ability to process the information may also increase. Hence, this study's results should be interpreted in light of this limitation and may not be generalisable to other time periods.

Third, given that the carbon disclosure scores based on sustainability reports (CDIS2) and the carbon risk management (CRM) scores were coded by the researcher, these measures are subject to subjectivity and bias problems. However, to enhance the reliability of these scores, the researcher trained in coding and developing these scores before starting the content analysis procedure.

6.5 Suggestions for future research

There are several opportunities for future research that arise from the limitations addressed in the previous section. First, employing several more proxies for estimating the ex-ante cost of equity capital is worthwhile. This would help in enhancing the validity of the estimates and reducing the measurement errors. Second, additional longitudinal investigation would be useful to affirm the absence or existence of a relationship between carbon risk management, carbon disclosure and capital market indicators in other time periods. Additionally, using a time-series design would be help in avoiding the impact of other omitted confounding variables that may affect this relationship.

Third, this study relied on archival (secondary) data in order to achieve its results. Hence, further research by interviewing firms' managers and institutional investors or conducting a number of case studies would be valuable. This would help to provide a more detailed understanding of the linkage between carbon risk management-disclosure and stock market performance from the perspectives of both management and investors.

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APPENDICES

Appendix 1 Carbon disclosure scoring index (CDLI 2009 methodology)

This appendix provides an explanation about the Carbon Disclosure Leaders Index (CDLI2009) methodology. It describes in detail the system used to assign scores to particular questions. As discussed in chapter 3, this methodology uses a mixed approach including the binary and weighting approaches to assure that the final score given to a firm reflects the quality of carbon disclosure. In addition, these approaches are applied to particular questions whereas these questions differ according to their applicability to a particular firm. Section 1 outlines the approaches used and the points allocated under each approach. Section 2 discusses how questions should be answered and how particular questions are applicable to particular firms. Section 3 details the scoring ranges and scoring index.

1- Scoring Types

a) **Binary:**

Scores may be either 0 or 1. One point is given for disclosure. Often the binary scoring type is applied to questions that only ask for one piece of information or where a straightforward yes or no answer is required.

b) **Data specific:**

Under this approach, individual points are awarded for providing specific data points which are detailed in the "description" column of the methodology. There are two variations on this approach. See below:

Data specific + condition

This approach applies ONLY to question 12.1. Data specific points are available for answers to question 12.1 PROVIDED THAT question 11.1 has also been answered.

Data specific or variable

This approach applies ONLY to questions 23.13 and 23.14 where data specific points are available for providing a quantitative response and the variable scoring type applies to qualitative answers.

c) Variable:

This approach is generally used for questions that require a qualitative or narrative response. There are two variable scoring approaches as follows:

Variable scale A

Up to 2 points – 1st point = detail that provides the reader with a complete and direct answer to the question, 2nd point = a good level of detail that is specific to the company.

Variable scale B

Up to 3 points – 1st point = detail that provides the reader with a complete and direct answer to the question, 2nd point = a good level of detail that is specific to the company, 3rd point = specific examples/case studies are provided.

d) Special:

This approach applies only to questions 10.1, and 11.1, where 3 points are given for disclosure of the information required. This reflects the relative importance attached to the provision of GHG emissions data.

e) No score:

Where questions are optional (for example, information is required only where it is necessary to give a more complete understanding of the responding company's business) or in some instances where questions are new to CDP 2009, no score is given. The questions concerned are nevertheless regarded as important.

2- Question types:

a) Stand-alone:

Stand-alone questions apply to all companies. Answers are not dependent on the response to any preceding subsequent question. They are scored in isolation regardless of answers to any other question.

b) Lead:

A "lead" question is the first in a series of questions, the answers to which depend on the response to the lead question. In many cases "lead" questions demand a yes or no answer (e.g.: Question 21.1) and the approach to subsequent questions in the series depends upon whether the answer is "yes" or "no" – hence subsequent questions are known as "conditional yes" or "conditional no" (see below). In other cases, "lead" questions ask for a piece of information for which further analysis is then sought (e.g.: Question 23.3).

c) Conditional Yes:

Generally, these questions apply where the lead question has been answered "yes" or where information has been supplied in response to a lead question and further analysis of that information is requested.

d) Conditional No:

Generally, these questions apply where the lead question has been answered "no" or where no information has been supplied in response to a lead question.

3- Scoring ranges and index

a) CDLI Scoring Ranges

Section number	section	Stand alone	lead	Conditional Yes	Conditional No	Max total assumes all questions answered and Yes to all lead questions	Range assuming all questions answered	Performance score total*
1	Risks & Opportunities	0	6	30	18	36	24-36	6
2	Emissions Accounting	34	10	7	4	51	48-51	9
3	Verification & Trading	7	9	23	1	39	17-39	3
4	Performance	14	10	12	1	36	25-36	13
5	Governance		4	10	2	14	6-14	6
	Total	**55**	**39**	**82**	**26**	**176**		**37**

*For the purpose of this research, performance scores refer to the carbon risk management scores.

b) CDLI scoring index

1- Risks and Opportunities

Question No	Question	Score Type	Stand Alone	Lead	Conditional Yes	Conditional No	Description	Performance Score	Description
1.1	**Regulatory Risks:** Is your company exposed to regulatory risks related to climate change?								
2.1	**Physical Risks:** Is your company exposed to physical risks from climate change?								
3.1	**Other Risks:** Is your company exposed to other risks as a result of climate change?								
	For each of the questions	Binary		1			Disclosed yes/no (1) or not (0)	1	The response describes actions the company has taken to manage, adapt to or minimise the risks identified.
		Data specific			5		5 Points: Response addresses points listed in right hand column on page 2 of the CDP 2009 information request (up to 3 points depending on the degree to which those points are addressed), financial implications of risks are described (1 point), answer contains information that is specific to the responding company rather than general observations about risk (1 point).	1	

		Data specific				3	3 Points: Response addresses points listed in right hand column on page 2 of the CDP 2009 information request (up to 2 points), answer contains information that is specific to the responding company rather than general observations about why risk does not apply (1 point).	1	
4.1	**Regulatory Opportunities:** Do regulatory requirements on climate change present opportunities for your company?								
5.1	**Physical Opportunities:** Do physical changes resulting from climate change present opportunities for your company?								
6.1	**Other Opportunities:** Does climate change present other opportunities for your company?								
	For each of the questions	Binary		1			Disclosed yes/no (1) or not (0)	1	The response describes actions the company has taken to maximise the opportunities identified.
		Data specific			5		5 Points: Response addresses points listed in right hand column on page 2 of the CDP 2009 information request (up to 3 points depending on the degree to which those points are addressed), financial implications of risks are described (1 point), answer contains information that is specific to the responding company rather than general observations about risk (1 point).	1	

		Data specific				3	3 Points: Response addresses points listed in right hand column on page 2 of the CDP 2009 information request (up to 2 points), answer contains information that is specific to the responding company rather than general observations about why risk does not apply (1 point).	1	
	Total for section			**6**	**30**	**18**		**6**	

2- Emissions accounting

7.1	**Reporting Year** Please state the start date and end date of the year for which you are reporting GHG emissions.	Binary	1				Disclosed yes/no (1) or not (0)		
8.1	**Reporting Boundary** Please indicate the category that describes the company, entities, or group for which Scope 1 and Scope 2 GHG emissions are reported. • Companies over which financial control is exercised – per consolidated audited financial statements; • Companies over which operational control is exercised; • Companies in which equity share is held; • Other (please provide details).		1				Disclosed yes/no (1) or not (0)		

8.2	Please state whether any parts of your business or sources of GHG emissions are excluded from your reporting boundary.	Binary	1				Disclosed yes/no (1) or not (0) Note, an answer is required in all cases either to confirm that all parts of the business/sources of GHG emissions within the reporting boundary are accounted for or to identify those parts of the business/sources of GHG emissions that are not accounted for.		
9.1	**Methodology** Please describe the process used by your company to calculate Scope 1 and Scope 2 GHG emissions including the name of the standard, protocol or methodology you have used to collect activity data and calculate Scope 1 and Scope 2 GHG emissions. Please also provide:	Variable	3				Standard Scale B		
9.2	Details of any assumptions made.	Binary	1				Disclosed (1) or Not (0)		
9.3	The names of and links to any calculation tools used.	Binary	1				Disclosed (1) or Not (0)		
9.4	The global warming potentials you have applied and their origin.	Binary	1				Disclosed (1) or Not (0)		
9.5	The emission factors you have applied and their origin.	Binary	1				Disclosed (1) or Not (0)		
10.1	**Scope 1 Direct GHG Emissions** Total gross global Scope 1 GHG emissions in metric tonnes of CO2-e	Special		3			Disclosed (3) or Not (0)		

	Please break down your total gross global Scope 1 emissions by:								
10.2	Country or region	Binary			1		Disclosed (1) or Not (0)		
10.3	Business division	No score					Optional Disclosure		
10.4	Facility	No score					Optional Disclosure		
10.5	Please break down your total global Scope 1 GHG emissions in metric tonnes of the gas and metric tonnes of CO2-e by GHG type.	Binary			1		Disclosed (1) or Not (0)		
10.6	If you have not provided any information about Scope 1 emissions in response to the questions above, please explain your reasons and describe any plans you have for collecting Scope 1 GHG emissions information in future	Data specific				2	Explanation of reasons (1), Description of plans (1)		
11.1	**Scope 2 Indirect GHG Emissions** Total gross global Scope 2 GHG emissions in metric tonnes of CO2-e Please break down your total gross global Scope 2 emissions by:	Special		3			Disclosed (3) or Not (0)		
11.2	Country or region	Binary			1		Disclosed (1) or Not (0)		
11.3	Business division	No score					Optional Disclosure		
11.4	Facility	No score					Optional Disclosure		
11.5	If you have not provided any information about Scope 2 emissions in response to the questions	Data specific				2	Explanation of reasons (1), Description of plans (1)		

	above, please explain your reasons and describe any plans you have for collecting Scope 2 GHG emissions information in future								
12.1	**Supporting Particular Types of Electricity Generation** If you consider that the grid average factor used to report Scope 2 emissions in question 11 above does not reflect the contractual arrangements you have with electricity suppliers, (for example because you purchase electricity using a zero or low carbon electricity tariff), you may calculate and report a contractual Scope 2 figure in response to this question, showing the original of the alternative emission factors and information about the tariff.	Data Specific + Condition	2				Figure (1) and detail on the origin of the alternative emission factors (1). A maximum of two points may therefore be scored PROVIDED THAT question 11.1. is also answered.		
12.2	If you retire any certificates (e.g.: Renewable Energy Certificates) associated with zero or low carbon, please provide details	Binary	1				Disclosed (1) or Not (0)	1	If certificates are retired

	Scope 3 Other Indirect GHG Emissions For each of the following categories, please: • Describe the main sources of emissions, • Report emissions in metric tonnes of CO2-e, • State the methodology, assumptions, calculation tools, databases, emission factors (including sources) and global warming potentials (including sources) you have used for calculating emissions								
13.1	Employee business travel	Data Specific	3				Description of Source (1), Emission Figure (1) Methodology (1)		
13.2	External distribution/logistics	Data Specific	3				Description of Source (1), Emission Figure (1) Methodology (1)		
13.3	Use/disposal of company's products and services	Data Specific	3				Description of Source (1), Emission Figure (1) Methodology (1)		
13.4	Company supply chain	Data Specific	3				Description of Source (1), Emission Figure (1) Methodology (1)		
13.5	Other	Data Specific	3				Description of Source (1), Emission Figure (1) Methodology (1)		
13.6	If you have not provided information about one or more of the categories of Scope 3 GHG emissions in response to the questions above, please explain your reasons and describe any	Data Specific	2				Explanation of reasons (1), description of plans (1)		

	plans you have for collecting Scope 3 indirect emissions information in future.								
14.1	**Emissions Avoided Through use of Goods and Services** If your goods and/or services enable GHG emissions to be avoided by a third party, please provide details including the estimated avoided emissions, the anticipated timescale over which the emissions are avoided and the methodology, assumptions, emission factors (including sources) and global warming potentials (including sources) used for your estimations.	Variable	3				Standard scale B	2	If the company has goods or services that reduce emissions by third parties.
15.1	**Carbon Dioxide Emissions from Biologically Sequestered Carbon** Please provide the total global carbon dioxide emissions in metric tonnes CO2 from biologically sequestered carbon.	Binary	1				Disclosed (1) or Not (0)		
16.1	**Emissions Intensity** Please supply a financial emissions intensity measurement for the	Variable		2			Standard Scale A, but award 2 points if no description given but explanation shows why the measurement is not relevant	6	The emissions intensity for each company will be calculated by dividing the total combined scope 1 and 2

	reporting year for your combined Scope 1 and 2 emissions, including a description of the measurement.								emissions (from companies' answers to questions 10.1 and 10.2) by their turnover (obtained from an independent source). Then for each industry sector: The third of the responding companies with the highest emissions intensities = 0 points The third of the responding companies with the middle emissions intensities = 3 points The third of the responding companies with the lowest emissions intensities = 6 points Where the population does not fall into three equal categories companies on the boundaries will fall into the higher score bracket.
16.1.1	The units, and	Binary			1		Disclosed (1) or Not (0)		
16.1.2	The resulting figure	Binary			1		Disclosed (1) or Not (0)		
16.2	Please supply an activity related intensity measurement for the reporting year for your combined Scope 1 and 2 emissions including a description of the measurement	Variable		2			Standard Scale A, but award 2 points if no description given but explanation shows why the measurement is not relevant.		
	The units, and	Binary			1		Disclosed (1) or Not (0)		
	The resulting figure	Binary			1		Disclosed (1) or Not (0)		
	Total for section		**34**	**10**	**7**	**4**	**Total for section**	**9**	

3- Verification and trading

17.1	**Emissions History** Do emissions for the reporting year vary significantly compared to previous years?	Binary		1			Note, 1 point is scored for selecting “yes”, “no” or “first year of estimation”.		
	If so, please explain why, and:	Variable			2		Standard scale A	3	If emissions have been reduced as a result of emissions reduction or energy efficiency activities.
17.1.1	Estimate the percentage by which emissions vary compared with the previous reporting year	Binary			1		Disclosed (1) or Not (0)		
18.1	**External Verification /Assurance** Has any of the information reported in response to questions 10 – 15 been externally verified/assured in whole or in part?	Binary		1			Disclosed (1) or Not (0)		
18.2	If so, please: State the scope/boundary of emissions included within the verification /assurance exercise.	Binary			1		Disclosed (1) or Not (0)		
18.3	State what level of assurance, (e.g.: reasonable or limited) has been given.	Binary			1		Disclosed (1) or Not (0)		
18.4	Provide a copy of the Verification /assurance statement.	Binary			1		Disclosed (1) or Not (0)		
18.5	Specify the standard against which the information has been verified /assured.	Binary			1		Disclosed (1) or Not (0)		
18.6	If not, please state whether	Binary				1	Disclosed (1) or Not (0)		

	you have plans for GHG emissions accounting information to be externally verified /assured in future.								
19.1	**Data accuracy** What are the main sources of uncertainty in your data gathering, handling and calculations e.g.: data gaps, assumptions, extrapolation, metering / measurement inaccuracies etc?	Variable		2			Standard scale A		
19.2	How do these uncertainties affect the accuracy of the reported data in percentage terms or an estimated standard deviation?	Variable			2		Standard scale A		
19.3	Does your company report GHG emissions under any mandatory or voluntary scheme (other than CDP) that requires an accuracy assessment? If so, please provide:	Binary		1			Disclosed (1) or Not (0)		
19.3.1	The name of the scheme.	Binary			1		Disclosed (1) or Not (0)		
19.3.2	The accuracy assessment for GHG emissions reported under that scheme for the last report delivered.	Binary			1		Disclosed (1) or Not (0)		
20.1	**Energy and Fuel Requirements and Costs** The total cost of electricity, heat, steam and cooling purchased by your company.	Binary	1				Disclosed (1) or Not (0)		
20.1.1	Please break down the costs by individual energy type.	No score							

20.2	The total cost of fuel purchased by your company for mobile and stationary combustion.	Binary	1				Disclosed (1) or Not (0)		
20.2.1	Please breakdown the costs by individual fuel type.	No score							
20.3	Your company's total consumption of purchased energy in MWh.	No score							
20.4	Your company's total consumption in MWh of fuels for stationary combustion only. This includes purchased fuels as well as biomass and self-produced fuels where relevant.	No score							
20.4.1	Please break down the total consumption of fuels reported in answer to question 20.4 by individual fuel type in MWh.	No score							
20.5	What is the total amount of energy generated in MWh from the fuels reported in question 20.4?	No score							
20.6	What is the total amount in MWh of renewable energy, excluding biomass that is self-generated by your company?	No score							
20.7	What percentage of the energy reported in response to question 20.5 is exported /sold by your company to the grid or to third parties?	No score							
20.8	What percentage of the renewable energy reported in response to question 20.6 is exported /sold by your company to the grid or to third	No score							

	parties?								
21.1	**EU Emissions Trading Scheme** Does your company operate or have ownership of facilities covered by the EU Emissions Trading Scheme (EU ETS)? If not, please proceed to question 22.	Binary		1			Disclosed (1) or Not (0)		
21.2	If yes, please give details of: The allowances allocated for free for each year of Phase II for facilities which you operate or own. Even if you do not wholly own facilities, please give the full number of allowances.	Data specific			2		Some years (1) or All Years (2)		
21.3	The total allowances purchased through national auctioning processes for the period 1 January 2008 to 31 December 2008 for facilities that you operate or own. Even if you do not wholly own facilities, please give the total allowances purchased through auctions by the facilities for this period.	Binary			1		Disclosed (1) or Not (0)		
21.4	The total CO2 emissions for 1 January 2008 to 31 December 2008 for facilities which you operate or own. Even if you do not wholly own facilities, please give the total emissions for this period.	Binary			1		Disclosed (1) or Not (0)		

22.1	**Emissions Trading** Please provide details of any emissions trading schemes, other than the EU ETS, in which your company already participates or is likely to participate within the next two years.	Variable	2				Standard scale A		
22.2	What is your overall strategy for complying with any schemes in which you are required or have elected to participate, including the EU ETS?	Variable	3				Standard scale B		
22.3	Have you purchased any project-based carbon credits?	Binary		1			Disclosed (1) or Not (0)		
	If so, please indicate whether the credits are to meet one or more of the following commitments: Primarily for compliance purposes, primarily for voluntary offsetting of your own emissions or other. Please also:	Binary			1		Disclosed (1) or Not (0)		
22.4	Provide details including the type of unit, volume and vintage purchased and the standard/scheme against which the credits have been verified, issues and retired (where applicable).	Data specific			2		Type, unit, volume & vintage (1) and scheme (1)		
22.5	Have you been involved in the origination of project-based	Binary		1			Disclosed (1) or Not (0)		

	carbon credits?								
22.6	If so: Please provide details including: your role profile in the project(s), the locations and technologies involved, the standard /scheme under which the projects are being/have been developed, whether emissions reductions have been validated or verified, the annual volumes of generate/projected carbon credits and the retirement method, if used, for own compliance or offsetting	Data specific			3		Six data points are listed on the ORS. Give 1 point for providing information on up to two data points, 2 points for providing information on up to four of the data points and 2 points for providing information on up to six of the data points.		
22.7	Are you involved in the trading of allowances under the EU ETS and/or project-based carbon credits as a separate business activity or in direct support of a business activity such as investment fund management or the provision of offsetting services?	Binary		1			Disclosed (1) or Not (0)		
22.8	Please provide details of the role performed	Variable			2		Standard scale A		
	Total for section		**7**	**9**	**23**	**1**	**Total for section**	**3**	

4- Performance

23.1	**Reduction Plans:** Does your company have a GHG emissions and/or energy reduction plan in place? If not:	Binary		1			Disclosed (1) or Not (0)	2	Yes (2) or No (0)
23.2	Please explain why:	Binary				1	An explanation of why answer is "No" (1) or Not (0)		
23.3	**Goal setting:** Do you have an emissions and/or energy reduction target(s)?	Binary		1			Disclosed (1) or Not (0)	2	Yes (2) or No (0)
23.4	What is the baseline year for the target(s)?	Binary			1		Disclosed (1) or Not (0)		
23.5	What is the emissions and/or energy reduction target(s)?	Binary			1		Disclosed (1) or Not (0)		
23.6	What are the sources or activities to which the target(s) applies?	Binary			1		Disclosed (1) or Not (0)		
23.7	Over what period/timescale does the target(s) extend?	Binary			1		Disclosed (1) or Not (0)		
23.8	**GHG emissions and energy reduction activities:** What activities are you undertaking or planning to undertake to reduce your emissions/energy use?	Variable	3				Standard Scale B	3	Bonus points if 3 points scored for disclosure.
23.9	**Goal evaluation:** What benchmarks or key performance indicators do you use to assess progress against the emissions/energy reduction goals you have set?	Variable			2		Standard Scale A		
23.10	**Goal achievement:** What emissions reductions, energy savings and associated cost savings have been	Data Specific			4		Explanation of Achieved Reductions, Savings to Date (2), Methodology (1), Data Sources (1)	3	If emissions reduction has been achieved.

	achieved to date as a result of the plan and/or the activities described above? Please state the methodology and data sources you have used for calculating these reductions and savings.								
23.11	What investment has been required to achieve the emissions reductions and energy savings targets or to carry out the activities listed in response to question 23.8 above and over what period was that investment made?	Data Specific	4				Description of Saving (1), Investment (1), Currency (1), Timescales (1)	1	If investment has been made.
23.12	**Goal planning and investment:** What investment will be required to achieve the future targets set out in your reduction plan or to carry out the activities listed in response to question 23.8 above and over what period do you expect payback of that investment?	Data Specific		4			Description of Saving (1), Investment (1), Currency (1), Timescales (1)		
23.13	Please estimate your company's future Scope 1 and Scope 2 emissions for the next five years for each of the main territories or regions in which you operate or provide a qualitative explanation for expected changes that could impact future GHG emissions.	Data Specific OR Variable		4 2			Global forecast figure provided for one year (1) Global forecast figure provided for one or more further years (1) Region/territory forecast provided for one year (1) Region/territory forecast provided for one or more further years (1) Or, Qualitative Answer (Standard Scale A) NB - maximum score for 23.13 is capped at 4	1	If emissions forecast appears to reduce in line with, or in excess of, with the target stated in 23.3.

23.14	Please estimate your company's future energy use for the next five years for each of the main territories or regions in which you operate or provide a qualitative explanation for expected changes that could impact future GHG emissions.	Data Specific OR Variable		4 2			Global forecast figure provided for one year (1) Global forecast figure provided for one or more further years (1) Region/territory forecast provided for one year (1) Region/territory forecast provided for one or more further years (1) Or, Qualitative Answer (Standard Scale A) NB - maximum score for 23.13 is capped at 4	1	If information suggests a downward trend in energy use
23.15	Please explain the methodology used for your estimations and any assumptions made.	Variable			2		Standard Scale A		
24	**Planning:** How do you factor the cost of future emissions into capital expenditures and what impact have those estimated costs had on your investment decisions?	variable	3				Standard Scale B		
	Total for section		**14**	**10**	**12**	**1**	**Total for section**	**13**	**Total for section**

5- Governance

25.1	**Responsibility:** Does a Board Committee or other executive body have overall responsibility for climate change? If not:	Binary		1			Disclosed (1) or Not (0)	1	Yes (1) or No (0)
25.2	Please state how overall responsibility for climate change is managed and indicate the highest level	Variable				2	Standard Scale A		

	within your company with responsibility for climate change. If so, please provide the following information:								
25.3	Which Board Committee or executive body has overall responsibility for climate change?	Binary			1		Disclosed (1) or Not (0)		
25.4	What is the mechanism by which the Board or other executive body reviews the company's progress and status regarding climate change?	Variable			2		Standard Scale A		
26.1	**Individual Performance:** Do you provide incentives for individual management of climate change issues including attainment of GHG targets? If so:	Binary		1			Disclosed (1) or Not (0)	1 1	Yes (1) or No (0) If they have stated that they have targets in place (23.3) and answer yes here
26.2	Are those incentives linked to monetary rewards?	Binary			1		Disclosed (1) or Not (0)	1	Yes (1) or No (0)
26.3	Who is entitled to benefit from those incentives?	Variable			2		Standard Scale A		
27.1	**Communications:** Do you publish information about the risks and opportunities presented to your company by climate change, details of your emissions and plans to reduce emissions?	Binary		1			Disclosed (1) or Not (0)	1	Yes (1) or No (0)

	If so, please indicate which of the following apply and provide details and/or a link to the documents or a copy of the relevant excerpt:								
27.2	The company's Annual Report or other mainstream filings.	Binary		1			Disclosed (1) or Not (0)		
27.3	Voluntary communications (other than to CDP) such as Corporate Social Responsibility reporting.	Binary		1			Disclosed (1) or Not (0)		
28.1	**Public Policy:** Do you engage with policymakers on possible responses to climate change including taxation, regulation and carbon trading? If so, please provide details	Binary Variable		1	2		Disclosed (1) or Not (0) Standard Scale A	1	If there is evidence in the company's response that it is engaging with policy makers in such a way as to encourage mitigation of climate change.
	Total for section			**4**	**10**	**2**	**Total for section**	**6**	**Total for section**