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Measuring the level of corporate commitment regarding climate change strategies

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Abstract

Purpose – This study aims to examine the various climate change practices adopted by firms and develop a set of corporate indexes that measure the level of climate change corporate commitment, climate change risk management integration and climate change strategies adoption. Moreover, this study examines the relationship between the aforementioned indexes. The authors claim that there is a positive relationship between the adoption of climate change strategies, corporate commitment and risk management integration. The aforementioned indexes have been used to assess the largest companies in the oil and gas sectors.

Design/methodology/approach – To assess this study's sample companies, a content analysis of their carbon disclosure project (CDP) reports for the years 2012-2015 was conducted. Finally, weights were assigned to the content analysis data based on the results of a survey regarding the difficulty of implementing each climate change practice included in the respective index. The survey sample included climate change experts who are either currently employed in companies that are included in the Financial Times Global 500 (FT 500) list, or work as external partners with these companies.

Findings – The present study results highlight the need for developing elaborate corporate indexes, as the various climate change practices have different degrees of difficulty regarding their implementation. Additionally, a general trend in adopting climate change strategies is observed, especially in the field of carbon reduction strategies, which mainly involve the implementation of low carbon technologies. Finally, a positive and significant relationship was found between carbon reduction targets, risk management integration and climate change strategies.

Practical implications – Although international research has extensively examined the importance of managers' perceptions on environmental issues as an enabling factor in developing environmental strategies, according to the results of our survey, corporations must go beyond top management commitment towards climate change to be able to successfully implement climate change strategies. Incorporation of climate change risk management procedures into a company's core business activities as well as the establishment of precise carbon reduction targets can provide the basis on which successful climate change strategies are implemented.

Originality/value – Most studies address the issue of climate change management in terms of environmental or sustainability management. Furthermore, research on climate change and its relationship with business management is mainly theoretical, and climate change corporate performance is measured with aggregate indexes. This study focuses on climate change which is examined from a five-dimensional perspective: top management commitment, carbon reduction targets, risk management integration, carbon reduction and carbon compensation strategies. This allows us to conduct an in-depth analysis of the various climate change practices of firms.

Keywords Risk management, Climate change strategies, Corporate commitment

Paper type Research paper

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1. Introduction

Climate change has been widely acknowledged as one of the major sources of risk by the global community. Taking as a reference the current flow of CO_2 emissions, it has been estimated that there is a chance ranging between 77 and 99 per cent that the global temperature will rise more than 2°C in the next 20 years (Stern, 2006). Such an increase in global temperature is most likely to cause rapid changes to current climatic models, affecting directly the natural environment. However, the risks that climate change poses are not confined strictly to the environmental and physical impacts of global temperature rise but they also involve social, economic and financial impacts (Cuevas, 2011).

The world-wide acceptance that climate change, as a result of the rise of CO_2 emissions concentration in the atmosphere, is attributed to human activities has triggered the adoption of policies both at national and international levels. These climate change policies aim to put a price on carbon emissions, for example, though carbon taxes, the establishment of carbon trading programs such as the European Union Emissions Trading System (ETS) (Chevallier, 2009), the setting of mandatory processes and product standards or the provision of incentives to invest in low carbon technologies (Bebbington and Larrinaga-Gonzalez, 2008). Moreover, institutional investors, banks, accounting firms, governmental agencies, NGOs and consumers have begun to demand information disclosure regarding the corporate climate change practices of firms (Maria Gonzalez-Gonzalez and Zamora Ramírez, 2016). Subsequently, there is a pressing need for businesses to develop appropriate climate change strategies for the risks posed by the projected climate change policies.

The aim of this study is to examine the various climate change practices adopted by firms and to develop a set of corporate climate change indexes that measure the level of climate change corporate commitment, the level of climate change risk management integration (RMI) into business activities and the level of adoption of corporate climate change strategies. Moreover, we examine the relationship between the aforementioned indexes. We claim that there is a positive relationship between the adoption of climate change strategies, corporate commitment and climate change RMI. Specifically, we develop two corporate indexes regarding corporate commitment: top management commitment (TMC) and carbon reduction targets (CRTs). Regarding climate change strategy, we distinguish between carbon reduction strategies (CRS) and carbon compensation strategies (CCS). Finally, we develop one index for climate change RMI. We use the aforementioned indexes to assess the largest companies in the oil and gas sectors for the years 2012-2015.

To assess our sample companies, we conducted a content analysis of their carbon disclosure project (CDP) reports for the years 2012-2015. Finally, we assigned weights to the content analysis data based on the results of a survey regarding the difficulty of implementing each climate change practice included in the respective index. The survey sample included climate change experts who are either currently employed in companies that are included in the Financial Times Global 500 (FT 500) list, or work as external partners with these companies.

The structure of this paper is as follows: in the next chapter, we conduct a review of previous research related to climate change strategies. Along with the relevant literature review, we develop our climate change indexes and present our research hypotheses. Then, we describe our scoring methodology, the development of the data weights and our regression model. Finally, we present the results of our survey, provide a discussion of our findings, outline the limitations of our study and make propositions for future research.

2. Conceptual framework

Regarding climate change, it is only recently that firms have begun to treat it as more than a corporate social responsibility issue. According to Porter and Reinhardt (2007), business leaders need to carefully examine the cost of emissions to their business as well as a firm's vulnerability to physical, economic and social impacts of climate change. Studying a firm's value chain and assessing its exposure to climate change can help them develop strategies that will not only reduce current and impeding climate change risks but also reveal business opportunities and enhance corporate performance. There are a number of different strategies that a firm can adopt and those depend on both the strategic choices of top management and its available resources (Lee, 2012; Christmann, 2000). Some firms may choose to make incremental changes regarding their business activities, while others may choose to make radical changes on their business model.

In one of the earliest papers on climate change strategy, Dunn (2002) briefly describes the technological, economic and policy implications of climate change on firms. Regarding the technological dimension, special attention is given to the use of alternative fuel sources, such as natural gas and renewable energy sources, as well as the development of efficient combined heat and power technologies. Also, the use of market-based instruments, such as carbon trading, is suggested as a way of lowering the cost of reducing CO_2 emissions. Weinhofer and Hoffmann (2010) divide climate change strategies into three different groups:

(1) *CO_2 compensation strategies*, which involve actions taken by firms to balance their carbon emissions by participating in emissions trading systems (ETSs), buying certified emission reductions credit units (CERs) or investing in emissions reduction projects.

(2) *CO_2 reduction strategies*, which focus on the improvement of CO_2 emitting production processes or on the design of new products, whose production emits fewer emissions.

(3) *Carbon independence strategies*, which are based on the design of processes and products that are carbon-free or which radically reduce carbon emissions.

Finally, Kolk and Pinkse (2008) also distinguish between innovation strategies and compensation strategies. They describe innovation strategies as process improvements that reduce energy consumption, such as the installation of energy-efficient technologies for carbon-intensive industries or the development of processes focused on the reduction of CO_2 emissions through the supply chain. Regarding compensation strategies, in the same line with Weinhofer and Hoffmann (2010), these include the internal transfer of carbon emissions through emissions trading and participation in carbon offset projects.

In this study, we develop two corporate indexes that measure the level of adoption of climate change strategies: the CCS index and the CRS index. Regarding the CCS index, in line with the aforementioned research, it incorporates the participation in emissions trading schemes, the creation of project-based carbon credits and the purchase of carbon credits. In relation to the CRS index, particular attention is placed on carbon-friendly technology and carbon reduction business processes. In this study, we are going to examine some indicative climate change technologies based on the research of Cadez and Czerny (2016). The following carbon reduction technologies are examined: natural gas, combined heat and power, renewable energy sources, carbon capture and storage and increased boiler efficiency. Finally, we examine the relationship between the aforementioned strategy indexes, two climate change corporate commitment indexes and one RMI index.

Regarding climate change corporate commitment and risk management, NGOs and research organizations have released several categorization schemes. More specifically, the CDP, the Coalition for Environmental Responsible Economies (Ceres), the Global Reporting Initiative (GRI), the Climate Disclosure Standards Board (CDSB) and RobecoSam classify managerial climate change strategies into three, broadly defined, categories: *Top Management Commitment*, which involves corporate commitment to climate change performance, top management responsibility and executive compensation; *Carbon Reduction Targets*; and *Climate Change Risk Management Integration* into core business strategy.

2.1 Relationship between corporate commitment and climate change strategy

Regarding climate change governance, high-level managers are generally considered as those who are in a position to make changes in an organization, to choose the business environment in which the firm operates and to engrave its course in the long term. In Linnenluecke *et al.*'s (2015) study on executives' perception on the need of developing climate change adaptation strategies, the authors find that engagement with climate change science and the perceived degree of the firm's vulnerability are positively related to the choice of developing climate change strategies. Therefore, examining the level of TMC in climate change is important in understanding the way climate change strategies are implemented within organizations.

The association between TMC and environmental or ethical commitment has been examined by international research (Boiral *et al.*, 2012, Aragón-Correa *et al.*, 2004; Weaver *et al.*, 1999; Henriques and Sadorsky, 1999). Results show that TMC in environmental issues is positively associated with increased corporate environmental commitment. Regarding climate change commitment, Jeswani *et al.* (2008) separate corporate climate change strategies into two categories: operational activities for energy efficiency and GHG reduction and management activities. Along those lines, TMC towards GHG reductions, the adoption of GHG reduction targets (both absolute emission reduction targets and business intensity targets) and the development of a corporate GHG inventory are examined as enabling factors for developing successful climate change strategies.

Moreover, Lee (2012) also proposes a set of carbon management activities. These include setting GHG reduction targets and developing a new market and new business activities. Moreover, organizational involvement, which is defined as top management involvement in climate change initiatives and encouragement of employees to undertake climate change initiatives, is also examined (Lee, 2012). Finally, the role of the vision, quality and skills of managers in the adoption of climate change strategies is also highlighted in the research of Boiral (2006). In this paper, we examine two aspects of corporate climate change commitment. The first one involves the commitment of top management towards climate change performance and the second is the adoption of CRTs. Based on the above, we develop the following hypotheses:

H1. There is a positive association between climate change strategy and top management commitment towards climate change.

H2. There is a positive association between climate change strategy and carbon reduction targets.

2.2 Relationship between risk management and climate change strategy

Climate change is characterized by a high degree of uncertainty and by the lack of sufficient prior data related to extreme weather events which can lead to "massive discontinuous changes" (Winn *et al.*, 2011). For that reason, the statistical methods based on historical data, the traditional probabilistic models used by insurance companies and the risk management analysis tools that exist today may prove to be insufficient in integrating quantitative and qualitative climate change risks into corporate operational activities (Winn *et al.*, 2011). This highlights the need to develop different risk management procedures that incorporate the principles of climate change risk management, climate change adaptation and resilience strategies into one integrated framework.

Perceived firm vulnerability to climate change physical risks is closely related to the perceived impacts of climate change, which include both the direct impacts on a firm's business operations and the indirect impacts on a firm's market and business environment. Moreover, it is affected by a firm's past experience with climate change risks, by the lessons learnt from previous extreme weather events and by its ability to quantify and assess the financial implications of extreme weather events (Pinkse and Gasbarro, 2016; Linnenluecke *et al.*, 2011; Linnenluecke *et al.*, 2008).

All of the above affect a firm's response to the physical risks of climate change. According to Pinkse and Gasbarro (2016), firms respond to climate change risk by taking either "routine measures" or "non-routine measures". Routine measures include developing risk monitoring and assessment procedures, taking technical measures to endure impacts, using financial instruments for risk sharing, developing emergency and restorations plans, etc. On the other hand, non-routine measures involve actions such as assessing the vulnerability of geographic sites of business activities, conducting product portfolio diversification by investing in alternative products or business procedures and driving cooperation within the industry to reduce climate change exposure.

Finally, implementing strategies, which enhance the adaptation and resilience of firms, greatly improves their ability to protect themselves to the adverse implications of climate change. However, for firms to successfully adjust to extreme weather events, they have to link both adaptation and resilience processes into one single action framework (Linnenluecke *et al.*, 2011). Building on the above, we form the following research hypothesis:

H3. There is a positive association between climate change strategy and climate change risk management integration.

3. Methodology

The aim of this study is to examine the various climate change strategies adopted by firms and to develop a set of corporate climate change indexes that measure the level of corporate commitment regarding climate change, the level of climate change RMI into business activities and the level of adoption of corporate climate change strategies. Based on extensive literature review, we developed five indexes related to climate change corporate practices:

(1) *Top management commitment* (TMC), which involves top management engagement and accountability.

(2) *Climate change risk management integration* (RMI), which examines how risk management processes are implemented by firms.

(3) *Carbon reduction targets* (CRT), long-term and short-term absolute reduction targets and intensity reduction target.

(4) *Carbon reduction strategies* (CRS), which include the development of carbon-efficient technologies and the implementation of business processes that reduce CO_2 emissions.

(5) *Carbon compensation strategies* (CCS), which involves carbon trading and CO_2 emission offsetting projects.

In total, 23 items were developed under these factors. The specific corporate practices related to each factor, and the related research, are presented in Table I. To measure the

Climate change index	Corporate practices	Related research	Item code
Top management commitment (TMC)	The Board of Directors (or a committee of the Board) is accountable for climate change performance	CDP (2015), GRI (2015), RobecoSam (2015), Ceres (2014), CDSB (2012), Boiral (2006) , Hoffman (2005), Renukappa *et al.* (2013)	ITEM_01
	Company management has clear responsibilities for achieving climate change goals	CDP (2015); GRI (2015), RobecoSam (2015); Ceres (2014), CDSB (2012), Hoffman (2005), Renukappa *et al.* (2013)	ITEM_02
	Executive compensation (monetary) is linked to climate change performance	CDP (2015), GRI (2015), RobecoSam (2015); Ceres (2014), Renukappa *et al.* (2013)	ITEM_03
Risk management integration (RMI)	Climate change risk management processes are integrated into core business risk management processes	CDP (2015), GRI (2015), CDSB (2012), Boiral (2006), Lash and Wellington (2007), Hoffman (2005)	ITEM_04
	Climate change risks and opportunities are identified at asset level	CDP (2015), GRI (2015), CDSB (2012); Hoffmann (2006)	ITEM_05
	Climate change risks and opportunities are identified at company level	CDP (2015), GRI (2015), CDSB (2012); Hoffman (2005)	ITEM_06
	Company has processes that allow the prioritization of risks and opportunities related to climate change	CDP (2015), GRI (2015), CDSB (2012)	ITEM_07
Carbon reduction targets (CRT)	Company has short-term absolute[a] CO_2 emission reduction targets	CDP (2015), CDSB (2012), Lee (2012), Jeswani *et al.* (2008), Hoffman (2005), Dunn (2002)	ITEM_08
	Company has short-term CO_2 emission intensity[b] reduction targets	CDP (2015), CDSB (2012), Lee (2012), Jeswani *et al.* (2008), Hoffman (2005), Dunn (2002)	ITEM_09
	Company has long-term absolute CO_2 emission reduction targets	CDP (2015), CDSB (2012), Lee (2012), Jeswani *et al.* (2008), Hoffman (2005), Dunn (2002)	ITEM_10
	Company has long-term CO_2 emission intensity reduction targets	CDP (2015), CDSB (2012), Lee (2012), Jeswani *et al.* (2008), Hoffman (2005), Dunn (2002)	ITEM_11
Carbon Reduction Strategies (CRS)	Fossil fuel switching, from coal to natural gas	Kotchen and Mansur (2016), Lamb *et al.* (2015), Cadez and Czerny (2016), IEA (2015), Dunn (2002)	ITEM_12
	Increased boiler efficiency, by implementing the best available technology	Cadez and Czerny (2016), Qu *et al.* (2014), Li *et al.* (2014), Namioka *et al.* (2012)	ITEM_13
	Usage of Combined Heat and Power Technology (cogeneration)	Gibson *et al.* (2016), Cadez and Czerny (2016), Lund and Mathiesen (2015), Klaassen and Patel (2013), Mago and Smith (2012)	ITEM_14
	Energy source switching, from fossil fuels to renewable energy sources	Cadez and Czerny (2016), IEA (2015), da Graça Carvalho (2012), Boiral (2006), Hoffmann (2006), Neuhoff (2005), Dunn (2002)	ITEM_15

(*continued*)

Table I. Climate change indexes and related research

Climate change index	Corporate practices	Related research	Item code
	Capture and storage of CO2	Cadez and Czerny (2016), IEA (2015), Boot-Handford *et al.* (2014), Gerbelová *et al.* (2013), Scott *et al.* (2013), Gunter *et al.* (2009)	ITEM_16
	Replacement of carbon-based products by non-carbon based products[c]	Cadez and Czerny (2016), Weinhofer and Hoffmann (2010), Jeswani *et al.* (2008)	ITEM_17
	Implementation of end-use energy efficiency processes[d]	Cadez and Czerny (2016), Jeswani *et al.* (2008), Boiral (2006), Hoffman (2005)	ITEM_18
	Optimization of current business processes in order to reduce CO2 emissions	Cadez and Czerny (2016), Weinhofer and Hoffmann (2010), Jeswani *et al.* (2008), Boiral (2006), Hoffman (2005), Kolk and Pinkse (2008)	ITEM_19
	Control of non-CO2 gas emissions (e.g. CH_4, H_2O)	Omara *et al.* (2016), Subramanian *et al.* (2015), Cadez and Czerny (2016), Brantley *et al.* (2014), Dunn (2002)	ITEM_20
Carbon compensation strategies (CCS)	Participating in emissions trading schemes	CDP (2015), Cadez and Czerny (2016), Lee (2012), Jeswani *et al.* (2008), Boiral (2006); Hoffman (2005), Kolk and Pinkse (2008), Dunn (2002)	ITEM_21
	Creating project-based carbon credits	CDP (2015), Cadez and Czerny (2016), Lee (2012), Jeswani *et al.* (2008), Boiral (2006); Hoffman (2005), Kolk and Pinkse (2008), Dunn (2002)	ITEM_22
	Purchasing carbon credits	CDP (2015), Cadez and Czerny (2016), Lee (2012), Jeswani *et al.* (2008), Boiral (2006); Hoffman (2005), Kolk and Pinkse (2008), Dunn (2002)	ITEM_23

Notes: [a]Absolut emission reduction refers to CO_2 reduction in absolute numbers, regardless of business activities; [b]Intensity ratios express CO_2 impact per unit of physical activity or unit of economic output; [c]e.g.replace plastic products with wooden ones; [d]e.g. turning down heating and cooling during non-working hours, reduce non-necessary travel, etc

Table I.

corporate indexes developed in this study, we conducted a content analysis of the CDP reports of the largest companies in the oil and gas sectors for the years 2012-2015. Finally, we assigned weights to the content analysis data based on the results of a survey regarding the difficulty of implementing each climate change practice included in the respective index.

3.1 Scoring methodology

The scoring methodology used in this study was based on a two-step procedure described later in the text. First, we conducted a content analysis of the CDP reports for each company by using the items included in the climate change indexes described above. "Content analysis has been defined as a systematic, replicable technique for compressing many words of text into fewer content categories based on explicit rules of coding" (Berelson, 1952; GAO, US General Accounting Office, 1996; Krippendorff, 1980; Weber, 1990). It is a method which "enables researchers to sift through large volumes of data with relative ease in a systematic fashion" (GAO, US General Accounting Office, 1996). Moreover, it allows us to "discover and describe the focus of individual, group, institutional, or social attention (Weber, 1990)." (Stemler, 2001). The method of content analysis has been used by many authors in studying corporate environmental disclosure reports (Freedman and Jaggi, 2005; Brammer and Pavelin, 2006; Prado-Lorenzo *et al.*, 2009; Gallego-Alvarez, 2010; Martínez-Ferrero *et al.*, 2015). We will also apply this methodology to analyze information provided in the CDP reports of oil and gas companies for the years 2012-2015. Each climate change index item takes the value of either 1 if the relevant information is reported or 0 if it is not.

After the content analysis was conducted, we assigned weights to the content analysis data based on the results of a survey regarding the difficulty of implementing each climate change practice included in the respective index. The reason we decided to weigh the content analysis data is because not all climate change practices have the same level of difficulty in their implementation. In Table II, we provide an example, which explains the reason why we decided to weigh the results of the content analysis. We measure the level of corporate commitment for CRS. As we can see, each company has different management practices. If we were to use simple content analysis, then corporate level of commitment for both companies would be the same, which in our example, is equal to 5. However, when we apply weights to the content analysis data, we observe that the level of corporate commitment for Company A (21) is higher than that of Company B (16).

3.2 Development of data weights

We assigned weights to the content analysis data based on the results of a survey regarding the difficulty of implementing each climate change practice described in Table I. The questionnaire was sent to experts in climate change corporate strategies. Respondents were asked to rate each climate change practice under a seven-point Likert scale (1 = Very Easy . . . 7 = Very Difficult), to indicate the difficulty level of implementing the respective corporate practice. The target sample involved climate change experts, who are either currently employed in companies that are included in the Financial Times Global 500 (FT 500) list or work as external partners with these companies. We selected climate change experts who are employed by large multinational companies or work with them because these companies have the organizational and financial capabilities to implement a large variety of climate change corporate practices. Therefore, we can assume that climate change experts employed, in this type of organizations, will have extensive experience on climate change corporate practices and can provide a more reliable assessment of the difficulty level regarding their implementation. Target respondents were identified via LinkedIn according to their expertise. Expertise was determined according to the target respondent's skills. To be included in the target sample, each respondent had to have the following skills in their profile: 1st skill: climate change; 2nd skill (at least one the following): strategy, management, strategic management, business strategy. Finally, for the skills mentioned above, target respondents had to have at least 30 endorsements from other members of the LinkedIn Network to be included in the target population of the research.

The questionnaires were sent via the LinkedIn InMail messaging service. In total, 332 questionnaires were sent and 188 complete questionnaires were received, representing a response rate of 56.62 per cent. To increase response rate, three reminders were sent to each target respondent. The first was after one week from the initial email posting, the second after two weeks from the initial posting and the third after four weeks from the initial email posting. The collection of questionnaires began on October 15, 2015, and completed on the March 23, 2016. The descriptive statistics of the final sample are presented in Table III.

Table II.
Example of scoring methodology for the carbon reduction strategies index

Carbon reduction strategies	Fossil fuel switching, from coal to natural gas	Increased boiler efficiency	Use of combined heat and power technology	Energy source switching, from fossil fuels to renewable energy sources	Capture and storage of CO2	Replacement of carbon-based products by non-carbon-based products	Implementation of end-use energy efficiency processes	Optimization of current business processes in order to reduce CO2 emissions	Control of non-CO2 gas emissions	Total unweighted score	Total weighted score
Median Values	4	3	4	4	7	5	2	3	4		
Company	0	1	1	1	1	0	0	1	0	5	
A	0	3	4	4	7	0	0	3	0		21
Company	1	1	0	1	0	0	1	1	0	5	
B	4	3	0	4	0	0	2	3	0		16

Sample characteristics	Response (%)	Response count
Gender		
Male	83.80	158
Female	16.20	30
Total	100.00	188
Age		
18-29	2.70	5
30-44	29.70	56
45-59	54.10	102
60+	13.50	25
Total	100.00	188
Level of education		
High school degree	0.00	0
Bachelor degree	18.90	36
Graduate degree	81.10	152
Total	100.00	188
Job description		
Engineering	2.70	5
Finance/Accounting	0.00	0
Human Resources	0.00	0
Management	48.60	91
Manufacturing	2.80	5
Project Management	5.40	10
Research	2.80	5
Risk Management	2.70	5
Sales/Marketing	0.00	0
Strategy/Planning	18.00	34
Other	17.00	32
Total	100.00	188
Job level		
Executive/C-Level	13.60	26
Senior Management	31.20	59
Middle Management	28.40	53
Intermediate	5.40	10
Entry Level	0.00	0
Other	21.40	40
Total	100.00	188
Industry sector		
Aerospace & defence	1.60	3
Automobiles & parts	3.19	6
Banks	11.17	21
Beverages	1.60	3
Chemicals	5.32	10
Construction & materials	6.38	12
Electricity	10.64	20
Financial services	6.38	12
Telecommunications	3.72	7
Food & drug retailers	1.06	2
Food producers	1.60	3

(*continued*)

Table III. Questionnaire sample descriptive statistics

Sample characteristics	Response (%)	Response count
Gas, water & utilities	6.38	12
General industrials	3.19	6
General retailers	2.13	4
Household goods & home construction	0.53	1
Industrial engineering	1.06	2
Metals & mining	4.26	8
Industrial transportation	1.06	2
Life insurance	0.53	1
Media	1.06	2
Nonlife insurance	2.66	5
Oil & gas producers	10.11	19
Oil equipment & services	4.26	8
Personal goods	2.13	4
Pharmaceuticals	1.06	2
Real estate investment	2.13	4
Software & computer services	0.53	1
Support services	0.53	1
Technology hardware & equipment	0.00	0
Tobacco	0.53	1
Other	3.19	6
Total	100.00	188
Experience in climate change related issues		
Less than 1 year	0.00	0
At least 1 year but less than 3 years	5.40	10
At least 3 years but less than 5 years	5.40	10
At least 5 years but less than 10 years	16.20	30
10 years or more	73.00	137
Total	100.00	188

Table III.

3.3 Regression model

After we conducted a weighted content analysis of the information in disclosed CDP reports of the sample firms, we developed a dependency model using the CCS and CCR indexes as dependent variables and the TMC, CRT and RMI indexes as independent variables.

$$\text{CRS} = f\,(\text{TMC, CRT, RMI}) \tag{1}$$

$$\text{CCS} = f\,(\text{TMC, CRT, RMI}) \tag{2}$$

The aforementioned model was empirically estimated using the following equation:

$$CRS_i = \beta_0 + \beta_1 TMC_i + \beta_2 CRT_i + \beta_3 RMI_i + \varepsilon$$

$$CCS_i = \beta_0 + \beta_1 TMC_i + \beta_2 CRT_i + \beta_3 RMI_i + \varepsilon$$

where CRS_i is the carbon reduction strategy index; CCS_i is the carbon compensation strategy index; TMC_i is the top management commitment index; CRT_i is carbon reduction target index; and RMI_i is the risk management integration index.

The aforementioned model was empirically tested using linear regression analysis and estimated using the ordinary least squares methodology.

4. Results

4.1 Survey results' descriptive data

The descriptive statistics of the climate change practices are presented in Table IV. As we can observe, the skewness and kurtosis values range between ±1 which indicate that data are close to normal distribution. Furthermore, regarding the TMC index, ITEM_03, which corresponds to the executive management compensation being linked to climate change performance targets, has the highest mean among the rest of the items. As far as CRTs is concerned, targets related to absolute CO_2 emission reductions generally receive a higher mean of implementation difficulty than intensity targets. Regarding carbon reduction technologies, *carbon capture and storage* has the highest mean difficulty, which can easily be explained if we take into account the fact that it is the newest carbon reduction technology and that it is considered to be at a demonstration stage. Finally, regarding CCS, participation in ETS and creation of project-based carbon credit have higher mean difficulty values than purchasing carbon credits.

4.2 Weighted content analysis descriptive data

Table V presents the descriptive statistics for the oil and gas companies for the years 2012-2015. According to above descriptive statistics, the adoption level of climate change practices varies to a great extent between companies. TMC and RMI have gradually increased for oil and gas companies during the past four years. Additionally, adoption of

Item code	Mean	Median	Skewness statistic	SE of skewness	Kurtosis	SE of Kurtosis
ITEM_01	4.22	4	−0.16	0.177	−0.732	0.353
ITEM_02	3.99	4	0.246	0.177	−0.947	0.353
ITEM_03	4.99	5	−0.482	0.177	−0.9	0.353
ITEM_04	4.12	4	0.111	0.177	−0.853	0.353
ITEM_05	3.62	3	0.58	0.177	−0.513	0.353
ITEM_06	3.76	4	0.337	0.177	−0.755	0.353
ITEM_07	4.03	4	0.196	0.177	−0.88	0.353
ITEM_08	4.8	5	−0.09	0.177	−0.617	0.353
ITEM_09	4.34	4	0.253	0.177	−0.813	0.353
ITEM_10	4.87	5	−0.471	0.177	−0.817	0.353
ITEM_11	4.47	5	−0.261	0.177	−0.908	0.353
ITEM_12	3.66	4	0.201	0.177	−0.247	0.353
ITEM_13	3.11	3	0.761	0.177	0.074	0.353
ITEM_14	3.64	4	0.227	0.177	−0.642	0.353
ITEM_15	3.76	4	0.071	0.177	−0.973	0.353
ITEM_16	6.37	7	−0.964	0.177	0.212	0.353
ITEM_17	4.64	5	−0.204	0.177	−0.507	0.353
ITEM_18	2.85	2	0.846	0.177	−0.001	0.353
ITEM_19	3.13	3	0.422	0.177	−0.609	0.353
ITEM_20	4.04	4	0.1	0.177	−0.967	0.353
ITEM_21	4.63	5	−0.555	0.177	−0.237	0.353
ITEM_22	4.82	5	−0.599	0.177	0.326	0.353
ITEM_23	3.38	3	0.394	0.177	0.111	0.353

Table IV. Survey results: descriptive statistics

Table V.
Descriptive statistics for oil and gas companies

Index	2012				2013				2014				2015			
	Mean	Median	Minimum	Maximum	Mean	Median	Minimum	Maximum	Mean	Median	Minimum	Maximum	Mean	Median	Minimum	Maximum
Board Oversight	8.66	8	0	13	9.81	11	4	13	9.41	11	4	13	9.97	11	4	13
Climate Change Risk Management Integration	11.84	15	0	15	12.06	15	0	15	12.44	15	0	15	12.53	15	0	15
Carbon Reduction Targets	4.53	4	0	14	4.84	4	0	14	3.72	4	0	14	3.75	4	0	10
Carbon Reduction Strategies	9.19	10	0	21	9.91	10	0	21	11.5	13	0	25	12.38	13.5	0	25
Carbon Compensation Strategies	5.31	5	0	13	6.03	5	0	13	6.41	6.5	0	13	4.84	5	0	13

CRTs has slightly decreased in 2014 and 2015 for oil and gas companies, while the rate of CRS has increased. On the other hand, we observe that the adoption of CCS increased until 2014 and decreased in 2015. Summarizing our results indicate a general trend in investing in low carbon technologies and a gradual shift from compensation strategies to CRS.

4.3 Results of empirical analysis

4.3.1 Correlation statistics. Table VI presents the bivariate correlations between the variables. The correlations between the variables are all positive and significant at the 0.01 level. The highest correlations are detected between RMI and both climate change strategy indexes. Furthermore, the CRT index also shows a very high correlation to the CCS.

4.3.2 Regression analysis. To estimate the ordinary least squares regression function, we analysed several statistical assumptions of the regression analysis, such as normality, homoscedasticity, multicollinearity and autocorrelation. Regarding normality, we applied the Kolmogorov–Smirnov test, which showed us that the variables do not exhibit a normal distribution. The lack of normal distribution is owing to the size of our sample and the existence of extreme values in our data. That is because firms will disclose a large amount of information, very little or none at all. Nevertheless, following Gallego-Alvarez (2010) and Lumley *et al.* (2002), we assume that the lack of a normal distribution does not affect the quality of our results. Regarding autocorrelation in the residuals from the regression, we conducted the Durbin-Watson test. The value obtained from the Durbin-Watson test is approximately 2, which reflects the absence of autocorrelation in the residuals. The variance inflation factors (VIFs) and tolerance factors have been used to analyse the absence or presence of multicollinearity. For there to be no multicollinearity problems, the values obtained in tolerance have to be high and the values obtained in the VIFs have to be low. The collinearity statistics presented in Table VII show that our models present tolerances

Correlations	TMC	RMI	CRT	CRS	CCS
TMC	1	0.438**	0.292**	0.276**	0.376**
RMI	0.438**	1	0.381**	0.503**	0.615**
CRT	0.292**	0.381**	1	0.415**	0.507**
CRS	0.276**	0.503**	0.415**	1	0.344**
CCS	0.376**	0.615**	0.507**	0.344**	1

Note: **Correlation is significant at the 0.01 level (two-tailed)

Table VI. Pearson's correlation

	Model 1			Model 2		
		Collinearity statistics			Collinearity statistics	
	CRS	Tolerance	VIF	CCS	Tolerance	VIF
TMC	0.029	0.790	1.266	0.084	0.790	1.266
CRT	0.257**	0.738	1.355	0.307**	0.738	1.355
RMI	0.392**	0.836	1.197	0.461**	0.836	1.197
R Square	0.312			0.471		
F	18.311**			35.923**		
Durbin-Watson	1.842			1.935		

Notes: $*p < 0.05$; $**p < 0.01$

Table VII. Regression statistics

between 0.790 and 0.836, and the VIF between 1.187 and 1.335, indicating the absence of multicollinearity.

Regarding the explanatory power of our models, these have R^2 values of 0.312 and 0.471 for a confidence level of 99 per cent ($p < 0.01$). These values are similar to those obtained in relevant studies. For example, Freedman and Jaggi (2005) obtained a value of 0.310 for the R^2, Prado-Lorenzo *et al.* (2009), 0.383, and Gallego-Alvarez (2010), 0.406. The results from the regression analysis, using the ordinary least squares methodology, are presented in Table VII.

For a confidence level of 99 per cent, CRTs and RMI have a positive and statistically significant effect on CRS and CCS. On the other hand, there is a positive but not significant relationship between TMC and both climate change strategy indexes. These results allow us to accept *H2* and *H3* and to reject *H1*.

Our results highlight the importance of climate change RMI into core business activities as an enabling factor in implementing corporate climate change strategies. In contrast to the results of relevant research, the effect of TMC on climate change strategies is not significant, while the adoption of CRTs is significantly related to both strategy indexes. Subsequently, setting CRTs and incorporating climate change risk management practices in core business practices contributes much more to the successful development of climate change strategies than TMC. These findings are particularly interesting because they stress on the need for business to go beyond the traditional corporate governance approach to environmental issues towards the establishment of a more concrete basis for implementing climate change strategies.

5. Conclusion

Climate change has been globally acknowledged as a major source of physical, economic and social risks. Companies are expected increased costs in their production processes and their supply chains, which will gradually affect their profitability. Moreover, the increased social and economic risks have also caught the attention of various stakeholders, such as institutional investors, banks, accounting firms, governmental agencies, NGOs and consumers who have been demanding information regarding corporate climate change practices. This study aimed to examine the various climate change practices adopted by firms and factors that influence the adoption of climate change corporate strategies. Subsequently, we developed two corporate indexes regarding climate change corporate commitment: *top management commitment* and *carbon reduction targets*. Regarding climate change strategy, we distinguished between *carbon reduction strategies* and *carbon compensation strategies*. Finally, we developed one index for climate change, *risk management integration*. We used the above indexes to assess the largest companies in the oil and gas sectors for the years 2012-2015.

Very few studies have attempted to address the issue of climate change management separately from the general concepts of environmental or sustainability management. Furthermore, the majority of research on climate change and its relationship with business management is theoretical and attempts to measure climate change performance that is based on the use of single aggregate indexes. Thus, the novelty of this study is that it focuses on only climate change and second that it does not use aggregate indexes to measure climate change corporate practices. Instead, we examine five different dimensions of climate change management which allow us to conduct an in-depth analysis of the various climate change practices of firms.

Our results show that there is a significantly positive relationship between carbon compensation and CRS, climate change RMI and CRTs. On the other hand, the relationship between the two carbon strategy indexes and TMC is deemed insignificant based on our results. This has practical implications for business, as it highlights the necessity of a coherent corporate climate change basis to enhance the success of both CRS and CCS. Although international research has extensively examined the importance of managers' perceptions on environmental issues as an enabling factor in developing environmental strategies, according to the results of our survey, corporations must go beyond TMC towards climate change to be able to successfully implement climate change strategies. Incorporation of climate change risk management procedures into a company's core business activities and the establishment of precise CRTs can provide the basis on which successful climate change strategies are implemented.

Our research has a number of limitations. First, to weigh our corporate climate change indexes, we used survey data based on the opinions of climate change experts. However, although our sample population was formed by experts who work in large multinational corporations, the data collected were based on the opinion of experts who work in multiple business sectors. In conducting our survey, we had to compromise with experts working in different sectors and not specific to the oil and gas sector, owing to the fact that our target population was very limited. We believe that in the future, we will be able to locate more experts of each respective sector to have more precise responses regarding the difficulty level of implementing climate change practices.

Future research could examine other economic sectors, and do comparative research between carbon-intensive and non-carbon-intensive sectors. Moreover, our indexes, used to measure corporate commitment regarding climate change strategies, could be examined in relation to corporate performance data. For example, researchers could use the indexes developed in the present study as dependent or independent variables in regression models to examined hypotheses related to the effect of climate change management in the financial performance of firms. This would also contribute to the general discussion regarding the win–win hypothesis of implementing both climate change strategies and achieving enhanced financial performance.

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